Industrialization and Development Strategies in the 21st Century: Towards Sustainable Innovation Systems

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August 2013

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Revised August 2013

Abstract:

The main purpose of this paper is to explore the possibilities of industrialization and development in the 21st century. With an ongoing global financial and economic crisis with only a tepid recovery at the time of this writing(August 2013) as well as the still unfolding ecological crisis, the 21st century presents an even greater challenge for industrialization in the developing world than the post-WWII period. The changed global economic and ecological environment will shape the emergence of new technological and industrial paradigms and trajectories in significant ways (Dosi 2000, Khan 2004a). However, while the main thesis of this paper argues for a radical rethinking of development and industrialization within an ecological political economy framework in the 21st century, there are still many relevant lessons---positive and negative--- from the post-WWII development and industrialization experiences and discourses. Therefore, the next section focuses on the development and industrialization experiences of the post-WWII period. This section also focuses in particular on the successful Asian economies in order to bring out a number of still relevant insights. Section 3 discusses the problems of industrialization and innovation in the particular 21st century context for China. The problems revealed through this case study can highlight many of the challenges of development, industrialization and innovation in the 21st century. However, it must be pointed out that China is also a special case in many respects and poses some problems for itself and for the smaller developing countries by the strategy of development it has followed so far. The research strategy here is to both avoid the danger of falling into overgeneralization and to emphasize the need for a radical change in both the global economic environment and specific development and industrialization strategies. This is highlighted in section 4 of this paper where the outlines of an alternative development strategy are given.

Keywords: Industrialization strategies, development strategies. Innovation, heterodox policies, industrial policies, China

JEL Classifications: O1, P1

1. Introduction

The main purpose of this paper is to explore the possibilities of industrialization and development in the 21st century. With an ongoing global financial and economic crisis with only a tepid recovery at the time of this writing(August 2013) as well as the still unfolding ecological crisis, the 21st century presents an even greater challenge for industrialization in the developing world than the post-WWII period. The changed global economic and ecological environment will shape the emergence of new technological and industrial paradigms and trajectories in significant ways (Dosi 2000, Khan 2004a). However, while the main thesis of this paper argues for a radical rethinking of development and industrialization within an ecological political economy framework in the 21st century, there are still many relevant lessons---positive and negative--- from the post-WWII development and industrialization experiences and discourses. Therefore, the next section focuses on the development and industrialization experiences of the post-WWII period. This section also focuses in particular on the successful Asian economies in order to bring out a number of still relevant insights. Section 3 discusses the problems of industrialization and innovation in the particular 21st century context for China. The problems revealed through this case study can highlight many of the challenges of development, industrialization and innovation in the 21st century. However, it must be pointed out that China is also a special case in many respects and poses some problems for itself and for the smaller developing countries by the strategy of development it has followed so far. The research strategy here is to both avoid the danger of falling into overgeneralization and to emphasize the need for a radical change in both the global economic environment and specific development and industrialization strategies. This is highlighted in section 4 of this paper where the outlines of an alternative development strategy are given.

It should be noted at the outset that even during the post-WWII period , as some have pointed out (e.g.,Amsden(2008), , Jomo(2007,2001,1995), Khan (2004a,b; 1997), there were at least two sub-periods. The first was an era of relative optimism during the Bretton Woods period of managed global capitalism. During this era, there was an overall strategy of development in the capitalist bloc that relied to a large extent on state-market synergy. It delivered fairly high growth for at least two decades in many countries but the distributional record was not impressive. Most importantly, the East Asian miracle with high growth and relatively benign distributional record throughout the entire post-WWII period(except the post-1990 record of China) also had its beginning during this era. Much of the infrastructural and human resources foundations for the subsequent growth and industrialization in the four tigers--- and in retrospect, for China and India--- were laid during these two decades.

The second period---now that much of the smoke from the last thirty years has cleared--- can be seen now as the demise of the Bretton Woods international financial architecture without any firm replacement except a dollar hegemony which now looks increasingly shaky. It is also seen as the era of Washington consensus which promised much but has delivered so far very little in the way of growth, investment and employment. Admittedly, both the periods were complex and a nuanced history is yet to be written; but the contrast is there. The rise of the Asian tigers including China and to some extent India has to be seen against this background. In this paper, the main argument regarding sustainable industrialization and development in this century is based on the idea of a complex economic system. The main conclusion is that while industrialization is both necessary and possible, a reasonable strategy must take into account the unevenness and complexity of the global economic system. Given that the developing countries themselves are at several different stages of development, there is no one-size-fits-all set of prescriptions. However, a nuanced and context-sensitive approach based on a realistic theory of development can still offer much help.

Writing in 1926, in a biographical essay on Edgeworth, Keynes underlined some of the problems of complex human systems:

We are faced at every turn with problems of organic unity, of discreteness, of discontinuity--- the whole is not equal to the sum of the parts, comparisons of quantity fail us, small changes produce large effects, the assumptions of a uniform and homogeneous continuum are not satisfied.[1]

If anything, the developing part of the world economy today shows to even a greater degree the kind of complexity captured in Keynes's words above. Fortunately, systems theory and economic theory have both made some progress since those dark days. Although we are far from a genuinely complete theory of complex economic systems, efforts are underway that have already borne some interesting fruit in several limited areas.[2] There are many facets of complex developing economies --each with its own sub-systemic characteristics to be sure, but there are also some common strategic features. The purpose of this paper is to partly synthesize from a strategic perspective--- to the extent it is possible to do so--- the development experiences of mainly the Asian economies with references to others(particularly the BRICs as a group and the Least Developed Coutries---the LDCs--- by way of contrast) and draw some appropriate lessons for industrialization and development in the 21st century..

2. Defining Development and Stages of Development and Some Common Strategic Features

However, at this point some clarification of the key term "development" is necessary in order to avoid ambiguities and confusions. In the rest of this paper, I will be referring to three concepts of development that are implicit in much of the discussion in the field of industrialization and development. The first is the idea of development as growth with some structural change or at least the idea that this type of growth is the most crucial necessary condition for development. The second concept is derived by adding explicit distributional elements to growth--- particularly inequality and poverty. Both these ideas are shared by the development economists today ---at least implicitly. In a recent contribution, Peter Warr is explicit in discussing all three---growth, absolute poverty and inequality[3]--- and his thoughtful essay alerts the reader to the performance of

[1] Keynes(1971-9), Vol. X, p. 261
[2] See for example, Khan(2004a,b, 2003a,, 1998,1997) and the references therein.
[3] At least since the McNamara period in the 70s, the World Bank took the lead in advocating "redistribution with growth". ILO and UNCTAD also followed suit and had stronger lines of argument.

Thailand in all three areas and derives--- at least partly--- a logic of further necessary reforms following from his cogent analysis of the three aspects of development in this sense. . He concludes:

Not all aspects of the Thai development strategy have been similarly successful. Inequality has increased at the same time as absolute poverty has declined. The underlying causes of this increase in inequality are still not well understood. (Warr 2008, p.22)[4]

The third--- and the broadest approach to development discussed here--- is in terms of Sen's idea of capabilities and its further extensions. In this view, development is really an extension over time and space of freedom,particularly the positive freedom to lead a certain type of life an individual has reasons to value. In technical modeling of industrialization and development (including my own models---see appendixes) often this normative view is not adopted explicitly. Yet, in so far as there is a normative aspect about development being a "(public) good" that is a premise for the whole project of industrialization and development such a view is consistent with the modeling approaches as well. In a recent essay prepared for WIDER, Keun Lee's perceptive comments on the possible role of democracy in development extends considerably the terrain of discussion in the direction of the "development as freedom" perspective when he writes:

We see obvious advantages in democracy, amongst which is the convenient feature that citizens are not subject to arbitrary arrest and torture. Truly strong states get it wrong more often than they get it right. Thus the military dictatorships of Latin America left little in the way of legacy ,whereas the military dictatorships in Korea and Taiwan (while not on anything like the same scale of brutality) left a powerful legacy of development. The difference lies clearly in strategic orientation and in institutional capacity in formulating and implementing a program of national industrial development. Our point is that this is an option available to the political leadership of any developing country today. On top of this, the key to the Korean or Asian success was institutional longevity. (Lee 2008, p. 13)

Sen did his earlier work on poverty in the 70s under ILO sponsorship. UNIDO and ECLAC both had always advocated industrialization and equity.

[4] See also Warr(1993,1999,2005) for nuanced analyses of the various aspects of Thailand's development experience and Jomo(2007,1995) for Malaysia..

It would seem, therefore, that there is an implicit agreement in at least the post-1970 thinking that development is "growth plus" other things. While the list of "other things" may vary somewhat, none of the researchers in the field today would equate growth and development. Yet, as almost all would agree that generating high growth may be a useful means towards development. Many thoughtful researchers also pay some attention to what can be called "the political economy of growth and distribution"

Synthesizing the Experiences of the high growth Asian economies further reveals some common strategic orientations as well as the effects of changes in external environment and shifts in policies over time. This is consistent with the characteristics of complex economic systems which are nonlinear with multiple equilibria and path dependence. Over time, one may observe the emergence of structural shifts in some cases, stagnation in other cases depending on initial conditions, strategies, policies and external environment among other things.In the Asian cases discussed here, there are many specific variations within each. However, they also share to various degrees many specific features listed below.

1**. Strategic Openness** to various degrees with Hong Kong, Singapore and Thailand being the most open and Viet Nam[5] the least. But in all cases there is a strategic commitment to export promotion beyond an earlier period of strategic import substitution(SISI)[6] and further goals of moving up the value added ladder. It should be kept in mind however, that there can be a "fallacy of composition"(Cline1982, Khan 1983,Mayer 2002, Razmi and Blecker 2006) in claiming that all developing countries need to do is to pursue an export-led growth policy. Reciprocal demands may not exist sufficiently and the ensuing competition for export markets in developed countries may create winners as well as losers. Therefore, what may be needed in the future for other aspiring countries is a strategic approach including the development of national and

[5] However, see Thoburn et. al.(2007) for an insightful and nuanced discussion of Viet Nam's trade-orientation and policies for the textiles sector.
[6] On what I have called SISI, see Amsden(2008) and the references therein, Bruton(1998)Khan(2004a,b;1997,1985,1982a,b)

regional markets and the creation of dynamic comparative advantage along with a number of other policies and institution building processes described below.

2. **Heterodox macroeconomic policies for stability**[7]---Here China and India have been the most heterodox. But Taiwan, Malaysia, Viet Nam and Korea display more of a mix of heterodox policies than Thailand.Even Hong Kong and Singapore at times have followed heterodox policies, esp. on the fiscal side. It seems that the rigidity of Washington consensus particularly in this area is rejected by the experiences of developing economies like China, India, Korea, Malaysia and Viet Nam.

3. **Creation of institutions for productive investment**---this exists in all cases, but Korea seems to have gone much further than the others much earlier.Starting with the reforms in the 1960s, it moved through several successive stages and is now trying to find appropriate technological niche in a world that is moving towards a convergence of information, bio and nano technologies by 2050. The role of state in the creation of these institutions is still very prominent.In this respect, China perhaps has the most ambitious agenda which is discussed as a special case study later.

4. **Agricultural development**--- all of them put enough of an emphasis but China and Viet Nam probably put through the most egalitarian pro-peasant development policies earlier. Korea and Taiwan also had an egalitarian land reform after the end of Japanese colonialism.

Warr(2008:p.12) describes the importance of agriculture in the Thai case:

> The results of the analysis indicate that agriculture's contribution to economic growth in Thailand included impressive rates of TFP growth. But its main contribution occurred through releasing resources which could be used more productively elsewhere, *while still maintaining output*, rather than through expansion of agricultural output. It is seriously wrong to characterize Thai agriculture as 'stagnant', based merely on the fact that output growth is slower in agriculture than in other sectors. If agriculture had really been 'stagnant' economic growth would have been substantially lower because it would not have been possible to raise

[7] See Jomo and Nagaraj(2001) for a good discussion of heterodoxy in this context.

productivity significantly within agriculture or to release resources massively while still maintaining moderate growth of output

Viet Nam's reforms in Agriculture are evaluated by Thoburn(2008) in the following words:

Rice, indeed, is the great success story of the agricultural reforms. Vietnam changed from being a net importer of rice in the 1980s to the world's third largest exporter (after the US and Thailand) in the mid-1990s, though there has been little further export growth since the late 1990s, particularly compared to other products …. This lack of growth is not necessarily surprising or a sign of failure. In the late 1990s, when rice export growth was peaking, less than 15% of output was being exported …. In an economy where around 70% of households were both consumers and producers of rice, rises in rice output were important primarily for raising rural incomes and for food security, with the surplus available for export varying with fluctuations in domestic production.

The state has played a role in encouraging new crops such as cashew, and later coffee …. Coffee is not straightforwardly a success story, though, as the expansion of Vietnam's coffee exports in the mid-1990s was a factor in causing a substantial fall in the world price.

5**. Industrial development and structural change**-- the strategic perspective in this important area suggests that the successful countries to various degrees pursued a continuously unfolding and dynamic set of policies with much trial and error. The retrospective attempts to tell a coherent story have often led to an overly deductive picture where good performances supposedly follow from a few , usually neoclassical economic principles. The Malaysian case study by Jomo and Wee is a good and convincing counterexample.Amsden(1989, 2008), Khan(1982a,b;1983,1997,2004a,b) and Wade(1990) discuss the cases of Korea and Taiwan in the general East Asian context.

Jomo and Wee(2008:p.10) describe some changes in strategy and policy for Malaysia within specific time-sensitive contexts:

Over the years, the government has changed its industrialization strategy. In response to problems and new priorities, the government announced the Second Industrial Master Plan (IMP2) for 1996-2005 in December 1996 to replace the (first) Industrial Master Plan (IMP) for 1986-1995. In September 1996, the government had set up the Multimedia Super Corridor (MSC) to promote certain information technology investments. The government committed over RM50 billion for infrastructure development to support this initiative. At the same time, the government strengthened intellectual property laws to reassure foreign investors and provided more generous incentives for new investments in this area.

Thus, the policy changes of the mid-1980s appeared successful in reviving growth and industrialization. Confirmation of the new policy direction from the mid-1980s came with the 1991 enunciation of Vision 2020, favouring growth, modernization and industrialization. Although FDI began levelling off in the mid-1990s, increased domestic investments – inspired by greater domestic investor confidence – sustained the momentum of rapid economic growth until the 1997-1998 regional crisis. The gravity of the crisis and the difficulties of recovery were exacerbated by injudicious policy responses, compromised by cronyism, though there is little persuasive evidence that cronyism itself precipitated the crisis.

They also point out changes in the sixties and seventies as well in response to changing global economic environment:

The decline of rubber prices in the 1960s must surely have affected economic performance and policy. Malaysia's experiment with import-substituting industrialization under foreign (principally British) auspices was quite different from most other developing countries where state-owned enterprises played leading roles as well as Northeast Asian experiences where effective protection was conditional on export promotion. Malaysia's transformation from net oil importer to exporter in the mid-1970s, when petroleum prices rose sharply, allowed the government to spend much more, while the recycling of petrodollars later allowed it to borrow from abroad at low cost until the Volcker intervention of 1980 raised real interest rates and precipitated a global recession, bringing commodity prices down. (Jomo and Wee 2008:p.14)

The case study of Viet Nam also confirms the suspicion that there is much that is improvised and *ad hoc* during the earlier phases of apparently successful development cases. The lesson here is perhaps to avoid major resource allocation distortions(as documented by the Thai case discussed by Warr also) and constant monitoring and policy revisions when existing policies do not work well.

6. **Creation of technological capabilities**--- here the Korean case stands out as a very apt illustration of creating technological capabilities throughout the entire growth and development trajectory in definite stages.[8]

As Lee(2008,pp.4-5) points out:

Among various aspects of capacities, emphasis should be on technological capabilities because without these, sustained growth is impossible. In this era of open market competition, private companies cannot sustain growth if they rely upon cheap products; they need to be able to move up the value-chain to higher-value added goods based on continued upgrading and improvement and technological innovation. Furthermore, private companies had better be "local" companies, whenever possible, including locally controlled JVs, not foreign controlled subsidiaries of the MNCs. MNCs subsidiaries are always moving around the world seeking cheaper wages and bigger markets. Therefore, they cannot be relied upon to generate sustained growth in specific localities or countries although they can serve as useful channels for knowledge transfer and learning.

The Malaysia case study by Jomo and Wee also recognizes this essentially strategic aspect of creating technological capabilities during medium to long run development. It is also clear from the China, Thailand and Viet Nam cases that strategic concerns with the creation of appropriate technological capabilities have been and continue to be very important.

7. **Technological learning and innovation**--- creating national innovation systems in particular requires the creation of specific institutions and technological learning over time. Ultimately, if development is to continue beyond the catching up phase, this may present the most crucial set of policy challenges. Here, the paper on Korea by Lee(2008) is an admirable attempt to sum up the lessons. There are specific features here to which Lee(2008,p.5) draws our attention.

Therefore, while the ultimate goal and criterion of development is to raise the capabilities of local private companies, the process needs pilot agencies to guide and coordinate the whole process. Such needs exist because key resources are so scarce, and thus had better… be mobilized for uses in sectors or projects with greatest externalities. As understood by Gerschenkron, who analyzed the latecomer industrialization of Germany and Russia, and identified latecomer agencies, such as

[8] See also Lee(2006) for a contrast of Korean experience with the Washington consensus and Khan(2008, 2002,1998 and 1997) for a discussion of the Korean (and Taiwanese)case(s) in the context of a distributionally sensitive growth model for positive feedback loop innovation system(POLIS). One possible nonlinear model of POLIS is discussed in the appendix.

large state-owned investment banks to drive the process in these countries, it is such agencies that can make up for gaps or lacunae in the country that is seeking to industrialize. All the east Asian countries built specific state-agencies that played a role of guiding the process of industrialization. In Korea the institutions established in the 1960s under the Park regime included the Economic Planning Board to set economic plans; the Ministry of Trade and Industry to support industrial policy and export; and the Ministry of Finance to finance economic plans.

Both state and civil society have to play important roles. At an earlier stage, the state necessarily plays a large and activist role . At a later stage, however, the creation of technological capability has to rely on a private-public partnership at both the precompetitive and the competitive phases of innovation(Khan2004a).

8. **Direct Foreign Investment and Foreign Aid---** these factors have played a role for all three but perhaps more so for Thailand, Viet Nam and Malaysia. Investment from abroad has perhaps been more significant than aid per se. However, internal generation of investible funds and public sector support have also played a crucial role---particularly in Korea, Taiwan and China. DFI in manufacturing sector can be important as the Viet Nam (and also the Thai and Malaysian cases) case shows:

Sectorally, manufacturing has been the most important area for DFI, with 51% of accumulated registered foreign capital over the 1988-2006 period, followed by transport, storage and communications (9.6%), mining and quarrying (8%) and real estate (8%) . (Thoburn 2008, p.8)

Not everything has to be of the best practice genre for DFI to come in as Thoburn shows for Viet Nam:

Paradoxically, Vietnam scores badly on conventional measures of competitiveness and investment climate, yet is highly regarded by foreign investors who operate in the country. The World Bank's *Doing Business* survey ranks Vietnam as 104th out of 175 countries as a good place to do business. In contrast, the *VDR* for 2007 claims that Japanese inward investors see Vietnam as the third most attractive investment location in the world. It seems that Vietnam's stable macroeconomic environment, high quality and low cost labour, and low levels of crime are more important considerations for investors than the details of bureaucratic procedures which are often included in international surveys. (Thoburn 2008 p.9)

Foreign Aid-- particularly Japanese aid--- has played a role in the development of Thailand and Malaysia but in the Asian cases the leveraging of aid for domestic development has perhaps been more important than the actual quantity of aid.[9]

9**. Poverty reduction strategies**-- these are a varied set of policies that are necessary in addition to growth. Although growth is a very important component of such a strategic approach to poverty reduction, in all cases specific policies targeting both rural and urban poverty were undertaken.Although in China, the period from 1995 on was a case of neglect or even reversal; but the current leadership seems to be aware of the political economic issues raised by such neglect and is committed publicly to reverse the reversal. In case of Thailand and Viet Nam, it can be argued, such attention for some time to come is still a necessary part of a coherent pro-poor development strategy. This suggests a "growth plus…"(Weiss and Khan2006) strategy for development.

In addition to the nine sets of factors discussed above, there are also somewhat random, historically contingent factors.The case study on Malaysia acknowledges the presence of such factors explicitly. But even a quick look at the other cases will reveal historically contingent events ranging from momentous events such as wars and revolutions to more usual changes in domestic and international political factors and changes in policies that depended on crucial personalities such as that of President Park in Korea in the 1960s. As Jomo and Wee (2008,p.14) indicate in summing up the lessons from at least five different policy periods in Malaysia:

It is difficult to evaluate policy success or failure simply in terms of subsequent economic performance. Malaysia's very open economy has often been subject to circumstances not of its own choosing or making.

The decline of rubber prices in the 1960s must surely have affected economic performance and policy. Malaysia's experiment with import-substituting industrialization under foreign (principally British) auspices was quite different from most other developing countries where state-owned enterprises played leading roles as well as Northeast Asian experiences where effective protection was conditional on export promotion. Malaysia's transformation from net oil importer to exporter in the mid-1970s, when petroleum prices rose sharply, allowed the government to spend much more, while the recycling of petrodollars later allowed it to borrow from abroad

[9] This is not to say that the quantity does not matter. Also for very poor countries today, aid can fill crucial financing gaps. See Khan(2003b) on these issues. For Japanese aid to China in infrastructural and energy related projects, see Khan(forthcoming,2009).

at low cost until the Volcker intervention of 1980 raised real interest rates and precipitated a global recession, bringing commodity prices down.

The Plaza Accord of September 1985 led to the strong yen just as Malaysia's sovereign foreign debt became yen-denominated. The mid-1980s' recession precipitated a banking crisis, which led to the 1989 banking reform to the seeming success of earlier deregulation facilitated financial liberalization, culminating in the 1997-98 crisis. The late 1980s' regulatory reforms encouraged further limited private foreign borrowings from abroad before that, limiting vulnerability on that front. The East Asian economic recovery from the last quarter of 1998, following the Russian and LTCM crises, similarly does not allow proper evaluation of the impact of Mahathir's controversial measures of early September as he moved to politically eliminate his deputy.

What follows from the above identification of both the relatively necessary as well as the more contingent factors that have played a role is, I think, the need for taking a pragmatic and diagnostic approach to the problems of development and industrialization in the 21st century. It is necessary to identify distortions. It is also equally necessary to identify market failures and other institutional failures. Instead of taking a grand, presumptive approach to development, the role of a mix of heterodox policies with the willingness to revise policies before the cost gets too high seems to be the best recipe for avoiding failures.

In looking at institution building in the Asian cases, it is also clear that generally, it is easier to list the functions that good institutions perform than it is to describe the shape they should take. In fact, consistent with the complexity approach outlined here, there may be a wide variety of institutions serving roughly the same function. From the Asian cases, it is apparent that the desirable institutions provide a rough and ready type of security of property rights, enforceability of contracts and lead to a gradual and strategically conceived integration with the world economy. In addition, they also help maintain macroeconomic stability without a necessarily rigid conservative fiscal stance. Over time and given sufficient financial development, the state and private sector institutions should be able to manage risk-taking by financial intermediaries. In order to promote equitable growth there will also need to be institutions that can supply social insurance and safety nets, and create a democratic space for voice and accountability. But there is no one-size-that-fits-all for any of these functions.[10]

As Warr points out insightfully in the concluding section of his study of Thailand, in the Thai case, rapid growth has also been accompanied by high inequality and environmental degradation.This also true of China(Khan forthcoming2009, Khan and Liu(2007)). One important lesson that follows from this is that even if a country is successful in growing through a combination of strategies, policies and circumstances, without explicit attention to equity and ecology, sustainable growth and equitable development may not occur automatically but rather the contrary may happen.[11] It is, then, an added imperative for the policy makers to include these salient goals in policy formulation and institution building. While no predetermined futures are foreordained in this complex world, some thoughtful diagnosis of these problems relatively early on may suggest solutions which can be implemented before it is too late.

To sum up, the Asian cases offer a set of concrete examples of the growth and development experiences during the post WWII period. Although no country can succeed by following mechanically the experience of another country , as outlined above, a number of helpful policy and institutional insights can still be drawn out from these cases. In the spirit of experimentation with rapid feedback and flexible policy making informed by a strategic medium to long run perspective, much can be done by the policy makers who are imaginative and pragmatic at the same time. Dynamic learning and flexible institution building are essential components of such a strategic approach to development. I now discuss the specific case of China in the specific area of building an innovation system for the 21st Century.

3. Chinese Industrialization and Innovation System: friend or Foe of Other Developing Economies?

[10] See Chang (2007) for a number of thoughtful contributions on this topic among other things.
[11] See also Jomo et. al.(2004) and Khan(1997 and 2004a,b)

This section[12] analyzes the available evidence of China's S&T, R&D, and innovative capabilities, to provide an assessment of the effectiveness and potentialities of its national system of innovation (NSI)), and to formulate some preliminary policy suggestions aimed at improving China's overall innovation strategy. This last item, it will be seen, leads to the formulation of a somewhat novel modification and extension of NSI in the complex economic systems context. The idea of a positive feedback loop innovation system(POLIS) which will be formalized to some extent later is an ecological political economy approach to innovation and development in the 21st century that can be useful for China and many other countries.

China's innovation strategy aims at embodying world-class best practices from technological world leaders and successful late industrializers, but is also peculiarly Chinese in at least two crucial aspects. The first is China's sheer size, which has allowed her to leapfrog to rank 2 worldwide in terms of the absolute quantitative magnitude of its NSI, at a stage when it still far lags behind all technological leaders in terms of per capita educational, technological, and research achievements. The second is China's specific form of market "socialism", which has the potential of conferring her leaders an outstanding advantage in the crucial area of strategic planning, i.e. the capability to master national resources and to earmark them towards key goals accordingly to a clear set of priorities.

China's goal is to engineer in a relative short period a decisive qualitative leap in her NSI, developing a systemic ability to generate world-class indigenous innovations. In addition to fostering technical progress, China's development strategy shall also take into account the challenge of establishing a model of innovation compatible with an equitable pattern of income distribution and environmental sustainability, thereby paving the way to the eventual evolution towards a higher and more developed form of socialism. This is the expressed aim of the Chinese leadership. However, the simple NSI approach is not necessarily sensitive to these strategic requirements, and therefore there is a need for more advanced analytical and planning tools. In this context, I propose to consider the utility of nonlinear models of the POLIS (positive feed back loop innovation system) class, which are suitable to chart strategically the market "socialist" course, as their internal logic is consistent with China's unique catch up strategy.

By the turn of the century, China's R&D sector was growing rapidly in size and effectiveness, yet a major reorientation of resources towards research activities had not materialized yet. Major policy changes had been taking place in the 1980s and 1990s, and China's R&D system was undergoing two main and apparently contradictory, but in fact potentially complementary transformation trends. On one hand, there was a powerful drive towards commercialization and decentralization. On the other hand, the government was earmarking large resources and according an increased degree of priority to a new generation of national research programmes. The innovative capacity and the technological level of Chinese productive enterprises were improving, particularly so in the state-owned sub-sector, where managing practices and property relations were undergoing major changes (Gabriele 2002). In the late 1990s and early 2000s China kept investing heavily in its R&D and S&T sector, and reforming its NSI. Similar patterns, to a lesser extent, were observed in other semi-industrialized developing countries.
In the meantime, further evidence is accumulating on the key role of R&D in boosting economic growth (see David et al. (2000), Arora et al (2007)) and on global technological trends, which point towards an ever-increasing divergence between developed and developing countries. Only China and (possibly)4 a very small group of other semi-industrialized countries are beginning to close the technological gap separating them from the world leaders (see Fagerberg, Knell, and Srholec (2007)). However, there are also signs of a sort of "research and innovation fatigue" which appears to be emerging in the developed world.

3.1. China's NSI and the linkages between industry and science

China's NSI has witnessed remarkable advances since the early 1980s, as a result of a series of reforms aimed mainly at improving its effectiveness and closing the excessive gap which traditionally separated university-based research activities from the technology absorption and innovation needs of the enterprises system. The main thrust of reforms has been to diversify the country's NSI and to strengthen its market-orientation (or market-compatibility), but the role of centrally-managed large, long-term research programs has also been enhanced. These reforms, along with the ever-expanding availability of financial resources made possible by economic growth and by the strong role of the national state, have allowed China to achieve remarkable advances. As a result, for instance, China's NSI is far superior to that of the other Asian emerging giant, India, in virtually every aspect (see Dahlman (2007), Schmitz and Stamm (2007), Kash, Augur, and Li (2004), Hung (2008)).

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[12] This section draws upon my joint work with Alberto Gabriele of UNCTAD. It does not reflect the official views of UNCTAD or any other UN organization.

Several organizational and institutional structures which proved their validity in the context of developed market economies are also being studied, experimented, and in some cases adopted in China, but such a pragmatic approach does not amount to an attempt to ape western examples. Actually, "It is far from clear that evolving into an innovation system similar to that found in developed market economies is a possible or even advisable objective for China or other countries emerging from central planning regimes and Soviet-style industrial organization….". On the contrary, "it is necessary to accept the possibility that fundamentally different but equally viable national innovation systems could emerge in China, other formerly centrally planned economies, or other nations with similarly very different legacies of industrial organization and social systems ….Policymakers would then be able to better evaluate which system structure is most appropriate, given the particular characteristics of their national context and the costs and likelihood of successfully introducing changes to move towards an alternative system structure" (Liu and White (2001), p.1112).

The most visible change in China's NSI is probably the progressive shift of the bulk of R&D activities away from universities and specialized research centres and towards industrial enterprises. However, universities participate in many of the most ambitious basic research endeavours, and often play a crucial role in their implementation. For instance, universities carry out about 1/3 of the "863 projects" and 2/3 of the projects funded by National Natural Science Foundation (NNSF) (Wu (2007), Hu and Jefferson 2004). In order to re-balance the roles of the different actors in the R&D scene in favour of the academia, the Chinese government is earmarking an increasing volume of funds to elite universities, mainly through the Ministry of Education (MOE). Elite universities are expected to lead in national R&D programs and projects, facilitate technology diffusion and pullovers, promote spinoff companies, incubation centres, and open laboratories for R&D sharing, to bridge foreign technology and partners. This emphasis on the role of universities in engaging directly in the development, production, and commercialization stages of their research results has been dubbed "forward engineering " by Lee. According to him, forward engineering is a peculiarly Chinese component of the "Beijing Consensus", a comprehensive and proactive catch-up strategy very different from the "Washington Consensus" and partly, but not fully similar to that followed before by other successful Asian latecomers such as Korea and Taiwan (see Lee 2006a, b and Lee, Hanh, and Justin Yifu 2002). Among other initiatives, a very important one was project 211, aimed at funding the construction of campuses and developing new academic programs in key scientific areas all over the country (Hsiung 2002) during the 1996-2000 Five year plan period.

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Other programs promote specifically university-industry links. The first one of this kind was launched jointly in 2001 by the State Economic and Trade Commission (SETC) and the MOE. The goal of this program was to set up state technology transfer centres in six universities, in order to promote the commercialization of technological achievements. After a long debate that concluded with the official position that universities have a threefold mission - research, teaching, and commercialization - MOE issued another directive in 2002, encouraging the development of university start-up enterprises. Research and technological innovations are seen as crucial channels through which universities contribute to national and local economies. (see Ma 2004, Zhang 2003, (Haiyan, Yuanlong and Kaiyuan 2006, Hong 2006, Motohashi 2005).

As mentioned above, however, the bulk of China's R&D is presently being carried out by enterprises, many of which are large SOEs. China's large SOEs not only did not die out, but have managed so far to resist and even to thrive after over a quarter-century of market-oriented structural changes. SOEs reforms were carried out in the framework of a complex, ever-changing and opaque institutional environment, characterized by a weak and ambiguous -albeit increasing- degree of protection of property rights in general and of intellectual property rights (IPR) in particular. Shedding light on this apparent (for orthodox economics) paradox, most studies on innovation among Chinese productive enterprises found that substantial progress was going on, and that SOEs were capturing the bulk of S&T resources, but exhibiting a less-than-satisfactory capability of translating them into true production improvements. The innovative capability of SOEs, however, appears to have been further enhanced in the mid-2000s6, thanks at least partly to the economies of scale and scope made possible by the "grasping the big, enlivening the small" policy. The combined profit of the 150 or so companies controlled by China's central government reached Rmb1,000bn (USD140bn), more than 200% higher than five years earlier. By end- 2007, the list of the world's 10 most valuable companies contained four groups controlled by the Chinese state7. The behaviour of Chinese SOEs is also becoming more modern and effective in a number of areas, including their ability to attract top executive talents (Dodson (2008).

In China as elsewhere, R&D expenditure is positive and significantly correlated with firm productivity. The contribution of government R&D to firm productivity works mainly through an indirect channel, via the promotion of firms' own R&D, which appears to be a more effective policy tool than direct R&D grants. Other key sources of production improvement and innovation growth are each firm's absorptive capacity, the production network, openness, and managers' education. Market-oriented, competition-enhancing innovation system reforms are improving the effectiveness of the incentive structure and fostering S&T linkage activities. With respect to the impact of ownership type, SOEs perform worse than collective and private firms in terms of production performance, but not in terms of innovation capabilities grants (Guangzhou Hu (2001), Guangzhou Hu and Jefferson (2003), Motohashi and Yun (2007)). The choice of innovation types among Chinese SOEs depends on the turbulence in the environment, and on the organizational resources, with market forces and internal governance simultaneously influencing SOEs' innovation patterns (Li, Liu, and Ren (2007)). In many SOEs, managers apply the technical innovation audit tool for benchmarking, thereby improving their ability to choose among different types of innovation mechanisms.

Due to the influence of the two main stakeholders (government and end users), firms with a higher degree of government involvement and a correspondently lower degree of openness to the market exhibit a more widespread use of innovation mechanisms, thereby apparently contradicting the positive relationship between market focus and innovativeness traditionally posited by "Western" innovation management theories. Therefore, "entering an open market abruptly may not be the solution for SOEs, which are rooted in a socialist economy, to become more competitive and more innovative" (Ren, Krabbendam, and de Weerd- Nederhof (2006). SOEs tend to prioritize the fulfillment of administrative tasks and "empirebuilding"ventures, whereas non-state firms tend to be more profitable in the market(Li and Xia (2008)). With the term "empire-building", Li and Xia refer to SOEs' managers' propensity (which they attribute to "agency problems"), to pursue "longterm investment and meeting new product output target, at the cost of high level of slack and inefficiencies…"(p.41). SOE's managers are "less concerned with the lack of legal protection of property right. Thus, compared with their non-state counterpart, they are relatively more likely to invest in projects with a longer payback cycle" (p.45). This phenomenon is due largely to strong government interference in SOEs' behavior, in a context of relatively weak IPR protection. The government puts a paramount emphasis on long-term investments and makes a great effort to promote technological innovations, targeting them as important indicators of SOE performance and awarding resources to SOEs accordingly). SOEs, rely more on government allocated resources, and therefore tend to perform better in areas that are encouraged by the government, such as new product development. As new product output is an important indicator of SOE performance, SOEs are incentivized to operate at thefrontier of new product development (Li and Xia (2008) ,MOST, 2005). In our view,in spite of the relevance of static inefficiencies and distortions, SOEs' "distorted" behavior in the static sense can be associated with dynamic advantages in terms of innovative capacity and technological progress, with major spillovers benefiting the national economy as a whole. One also needs to take into account the existence of virtuous synergies with the non state-owned sector.

Notwithstanding China's NSI's remarkable strengths, remaining challenges are formidable. For instance, Wang (2006) identifies a dualistic pattern in China's of technological development, with the export-oriented segments of the economy being relatively isolated from those producing mainly for the domestic market. Zeng and Wang (2007) stress the weight of constraints such as an insufficiently developed institutional framework, relatively low overall educational attainments, the lack of a large pool of world-class talents, the embryonic stage of indigenous innovation capacity, and insufficiently developed linkages between R&D and industrial enterprises. Other researchers point towards China's persistent weaknesses in technological cooperation between universities and industry, the inadequate integration of the country's NSI into the global innovation networks, and the need to develop a comprehensive , more refined technological strategy in order to achieve effective technology transfer from foreign technological leaders, while at the same time maintaining an appropriate balance between indigenous innovations and technology imports (see Li-Hua (2007), Haiyan, Yuanlong and Kaiyuan (2006), Li-Hua and Simon (2007)).

3.2 Recent evidence on China's innovative capabilities

3.2.1. Indirect and comparative evidence on China's technological progress

Growing quantitative evidence is becoming available on various aspects of China's economy, institutions, and innovative capabilities, and they broadly converge

towards suggesting that China is in fact climbing fast the economic and technological development ladder. Figures on economy-wide and industrial GDP, export, and labor productivity growth are too well known to be worth mentioning here. S&T, R&D and high-tech trade indicators are discussed in Section 3.2.2. Various other sources mention statistics bearing indirect evidence of China's growing technological power. Fortune's 2007 list of the top 500 global corporations includes 24 Chinese firms, four more than in the previous year. This figure is still far from that of US global companies (162), and also quite lower than Japanese, French, and German companies, but it's higher than the number of Korean, Indian and Taiwanese companies (Yoshida 2007).
Intriguing comparative evidence on companies' productivity growth and propensity to innovate appear to show that Chinese firms are doing reasonably well, European firms are maintaining their positions and (surprisingly) US firms are losing ground (see Suh 2008). Productivity growth in China is more than three times the rate of that in the US and Europe. A survey carried out on more than 500 chief information officers (CIOs) in the US, Europe, and China provides even more striking results. Only 32 % of US executives and 41% of Europeans said they wanted to be early adopters of new technologies, compared to 70% of Chinese CIOs (Mayberry, Wang, and Suh 2006. see also Accenture 2007, 2008). Consistently, 70% of companies in China are committing most of their business to web services, against 42% in Europe and 38% in the US: "As companies use these new standards for communicating with other systems, people and companies, they cut manual business process costs to one- tenth of current levels and can flexibly change features and services in less time for substantially less money….. Newer systems, during this second wave of web-based innovations, outperform older technology. These technologies have improved substantially in the past five years, making them easier to implement. As a result, more business processes will be online, driving higher levels of productivity" (Suh 2008). Moreover, many indicators on productivity, revenue and profit growth show that US companies are doing significantly worse than what conventional data on productivity growth might suggest. Among US S&P 500 large companies, employee growth was faster than both revenue and profit growth in 2001-2005. Thus, the growth of average revenue gains per employee was 58% lower than total average revenue growth, and profits per employee growth were only 75% of total profit growth. In contrast, among US S&P 350 companies recorded revenue and profit growth rates higher than employee growth rates.
Further indirect evidence of major advances in the areas of governance, management, and technology in China's industry is provided by the very marked improvements in SOEs' economic and financial performance. In the aftermath of the 1997 Asian financial crisis, China's SOEs sector, long plagued by the traditional deficiencies common to most publicly-owned productive enterprises, saw its average profit margins fall close to zero, with many firms reporting big losses. The prevailing wisdom, even among many Chinese observers, was that "since good performance does not guarantee that the incumbent manager will stay long, the manager does not have long-term incentives…. these built-in problems of state ownership cannot be solved by state-dominated corporatization…To ensure that only high ability people will be professional managers and that managers can be well disciplined, the authority of selecting management must be transferred from bureaucrats to capitalists. This

calls for privatization of both state enterprises and state banks "(Zhang 1998).
After ten years of restructuring, which implied a dramatic decrease in employment and in enterprise numbers but also massive injections of capital and technology and a major leap in managers' and workers' education and skills, the SOEs sector is in good financial health. In 2007, the profits of the core 152 firms controlled by the central government was about Rmb 1000 bn (USD 140 bn), more than 30% higher than in 2006 and over 200% higher than five years earlier. The rate of return was 11.7%, 1.3% higher than in 2006. 139 enterprises (more than 90 percent of core SOEs) increased their profits year-on-year… period, and 18 of them recorded profits of more than 10 billion Yuan, against 14 a year earlier" (Chinaview 2007). Shipbuilding, automotive and shipping enterprises are becoming significant profit earners, along with petroleum, power generation and telecom companies.
In this respect, there is a sub-sector that of cellular phones, where Chinese enterprises might soon achieve global leadership, thanks inter alia to their unique technological change pattern. Domestic producers' competitiveness in the world's largest cell phone market has been buoyed by the Chinese government's October 2007 decision to eliminate all licensing requirements to manufacture and sell mobile phones in the country, thereby opening the gate for newcomers, some of which have been selling phones in the black market. Differently from Japan, which has been quite innovative in the past but mainly produced models sold only in the local market, China is presently using the same technologies as the rest of the world. This important difference could induce Chinese manufacturers to launch fast-forward innovations with the goal of increasing their domestic market share, thereby ending up producing phones that will be competitive (ex post) also in foreign markets. New Chinese brands are making progress in the areas of brand name, research and marketing development, and appear on the way to close the gap with foreign brands. They might be particularly successful in the huge and fast-growing rural market, Rural customers are more price-sensitive than in the cities and "do not have strong brand loyalty, so they buy things which can give them the best value. To cater to such values, home-grown brands pack more features into their phones, making people think they can get more value from these products…Among the new entrants of home-grown handset vendors; Beijing-based Tianyu is a rising star. It expects to sell 13 million mobile phone units in 2007, a 113.1% growth year-on-year to become the third biggest domestic handset vendor in China. …" (Chung 2007). Other strong and innovative firms are CECT (which has launched a model with biometric security features) and Meizu. These companies "seem to be building up a global customer base attracted by the feature sets of the phones, which aren't provided by the global brands…. It's also pretty inevitable that there will a breakthrough product, one that just happens to meet an unexpected demand, and that will really bring Chinese phones to global attention"(Trigram.wordpress.com 2007).
In sum, China is trying to create a group of larges leading SOEs in highly competitive sectors, where technology, design and marketing capabilities are key for ultimate survival, thereby overcoming a traditional weakness of public enterprises worldwide (Dyer and McGregor (2008). The ultimate outcome of this major upgrading and restructuring exercise in China's public industry will clearly play a crucial role in shaping the country's development model.

3.2. 2. R&D and S&T indicators

. Input indicators show that China not only earmarked huge and ever-increasing resources towards research, science, and technology, but also intensified its efforts in relative terms, thereby exposing a strong and effective pro- R&D and S&T bias in both government and business sector policies. Gross Domestic
Expenditure on R&D in nominal terms almost tripled (in nominal terms) in the early 2000s, reaching 300 bn Yuan by 2006. In a period of very fast economic growth, the GERD/GDP percentage ratio also increased markedly, from .95 in 2001 to 1.42 in 2006. This figure is beginning to approach the 2% benchmark which is commonly considered a rule-of-thumb indicator signaling that "a country is sufficiently technologically sophisticated to help ensure technology-led economic growth." (OECD 2007). The business sector is the main contributor to total R&D expenditure (almost 70% in 2006), with most of the remainder being provided by the government. Sector-wise, over 70% of China's R&D is carried out by the business sector (which also employs almost 2/3 of the country's R&D personnel) and about 19% by research institutes. 70% of China's R&D workforce focuses on experimental development, 20% on applied research and almost 10% on basic research.

Roughly a half of total R&D is concentrated in the manufacturing industry, representing about 2% of its total value added. However, the latter indicator is more than twice as much in the high-tech industries, and reaches almost 14% in the aircraft and spacecraft sub-sector (see Table 1.3). Government S&T appropriation reached 168.8 bn yuan in 2006, more than twice the corresponding figure for 2001. Government S&T appropriation also increased as a percentage of total government expenditure (3.7 in 2001 to 4.2 in 2006), with a high level of priority being accorded to special projects and operating funds. S&T personnel reached over 4 million and R&D personnel (mostly scientists and engineers) 1.5 million.

Patents granted by SIPO (State Intellectual Property Office of the People’s Republic of China) in 2006 were almost 270000, more than twice the corresponding figure for 2002 and six times that of 1996. Over 22000 patents were granted to Chinese nationals (up from about 17000 in 2005) and 44000 to foreigners. However, most domestic patents were granted for utility model and design innovations. In the subset classified as true "inventions", successful foreign applicants outnumbered Chinese nationals, although the share of invention patents granted to the latter (43%) increased from that of the previous year (39%). Over half of all domestic service invention patents were generated in the business sector.

China published over 400 thousand S&T papers in 2006, almost twice as much as in 2001.More than half were produced by universities, but the fastest rate of increase was recorded by publications stemming from medical institutions. Chinese S%T papers indexed by SCI, EI, and ISP were 172 thousand in 2006, almost three times more than in 2001. The share of Chinese S%T papers indexed by the main international specialized institutions also rose significantly, reaching more than 42% by 2006.

China's high-tech trade expanded at an extremely fast pace. Exports increased twenty-fold in 1996-2006 period, reaching 2.8 USD bn by the end of the period. Their relative weight also rose, and by 2006 it had climbed to about 30%, both with respect to manufacturing exports and to total exports[9]. High-tech imports increased at a slightly slower pace, and as a result the high-tech trade balance turned positive in 2006 for the first time . China's high-tech trade is heavily concentrated on the computers & telecom sub-sector, with over 2.2 bn exports and a 1.5 bn surplus in 2006 .

Available simple international comparative indicators of R&D inputs and outputs confirm the basic features of an overall scenario in which China has undoubtedly joined the worldwide Ivy League, pouring towards the research sectors enormous and ever-increasing human and financial resources. China's R&D effort far outpaces that of other large, semi-industrialized countries such as Brazil and India, is far ahead of many countries formerly seen as among the most industrialized ones, such as Italy. However, they also show that China still lags behind the US and the other members of the small group of world technological leaders in the most advanced areas. In terms of R&D intensity of the national economy, measured by the GERD/GDP percentage ratio, China has clearly left behind Italy, Russia, Brazil, and India, but still lags behind the four world R&D leaders: US, Germany, Japan, and Korea. The two Asian countries, in particular, lead the field in terms of R&D intensity with GERD/GDP ratios close to or larger than 3%, more than twice China's ratio (Table 4.1.). Data on the distribution of GERD resources confirm the findings reported in para 3.1., above, i.e. that China's R&D activity - consistently with its present level of technological development - is much less focused on basic research than that of any other major player, including Russia. The absolute size of China's R&D personnel army (over 1.5 mn) far outnumbers that of any other country, yet in relative terms (R&D personnel per 10,000 labor force) it is less than one tenth that of Japan, Germany, and even Russia .

In absolute, nominal (i.e. dollar-denominated) terms, China's Gross Domestic Expenditure on R&D appears to be only slightly over one tenth of that of the US, one fifth of that of Japan, and half that of Germany (still, it is over four times higher than Russia's and Brazil's). However, in this case the MOST data, albeit formally correct, are misleading, as they might induce to unduly underestimate China's true strength vis a vis the rest of the world: "While the dollar figure on China’s R&D spending is dwarfed by that of Japan and the U.S., the real value of its expenditure is higher, thanks to lower costs – putting China third globally, on the basis of purchasing power parity" (HIKPA 2006). In fact, the international R&D expenditure figures expressed in purchasing power parity (PPP)[10] estimated by the OECD terms show a dramatically different picture. Having been growing at an exceptionally high annual rate of over 20% (more than five times that of any other major industrial country), China's R&D expenditure reached 136 bn USD in 2006, the second largest in the world, surpassing that of Japan and equivalent to more than one third that of the US .

Basic comparative indicators of international R&D outputs appear[11] to show that China - having reduced rapidly its relative backwardness, especially in the early 2000s - figures among the global leaders, as it ranks 4th worldwide in terms of domestic invention patents granted, 2nd in terms of indexed papers published, and 5th in terms of SCI-indexed papers published . These data, however, are not adequate to provide firm evidence on a much-discussed issue, i.e. whether China's ability to translate R&D inputs into output is structurally lower than that of world technological leaders.

3.2.3. Accumulation and technical progress

Felipe et al. (2008) apply a Classical analytical framework to analyze in a comparative fashion the diverging patterns of capital accumulation, profit rates, investment rates, capital productivity, and technological change of China and India between 1980 and 2003. Their findings can be propedeutic to a deeper discussion on the relationship between China's pattern of economic development and its unique socioeconomic structure.

China's accumulation process has been much faster than India's, thanks to China's investment rate (i.e., investment/GDP ratio), due in turn mainly to the fact that China has been reinvesting almost all her surplus, while India invested a much lower share.. In fact, as a World Bank study has recently pointed out, corporate sector saving – including by SOEs – is a key contributor to China's high rates of saving and investment: "At about 20 percent of GDP – double the share in the U.S. and France – retained earnings finance more than one-half of enterprise investment." (Kuijs, Mako, and Zhang 2005, p.3). Another important, and apparently contradictory finding, is that profitability has been rising constantly in India, but declining in China, so that the profit rate was much higher in the latter by the late-1990s. More worryingly, capital productivity[12] declined in China, while it rose in India[13], and - consistently - technical change was "Marx-biased" (i.e. of the labor saving, capital consuming type) in China, while it was broadly Hicks-neutral in India.

In sum," India differs from China in terms of how much profit has been plowed back into investment. In China virtually all profits are reinvested, with the consequence that actual investment has outstripped the capacity provided by profit and has led to the creation of overinvestment and overcapacity. Why is so much profit reinvested in China? A large part of these profits come form State Owned Enterprises. These companies do not pay dividends and face incentives that are biased toward investment, as local officials are promoted largely on their success in generating economic growth, which comes through investment. Thus, a large part of these profits is used for capital expansion (as much as 20% of all investment in China comes from local governments) without efficiency considerations…" (p.752).

The policy - initiated in 1994 - of non-payment of dividends was initially justified by the feeble and declining profitability of public enterprises, and by the need to recapitalize SOEs in the framework of a deep reform process aimed at streamlining and strengthening state industry, but by the mid-2000s it had been made obsolete by its own success. Actually, " The current non-payment of dividends implicitly assumes that there is no better use of SOE profits other than re-investment back into SOEs. Clearly, however, China faces urgent challenges in refocusing its public spending to improve key services. " (Kuijs , Mako and Zhang, 2005, p.7). It is also clear that, as a result of this policy, SOEs have been investing more than they would have had otherwise. The Chinese government has acknowledged this problem[15], and began in 2008 to enact a cautious and still experimental policy change, collecting a

modest (5-10%) share of the profits of state firms under its direct control. The destination of these dividends has not been clearly specified yet, but they are expected to be channelled to both social consumption (i.e., financing social security funds) and investment in high technology sectors (see China Daily 2007, China.org.cn 2007, Shanghai daily (2007), Naughton 2008). This development surely goes in the right direction, but is still probably insufficient even to achieve the simple goal to curb excessive investment (see Chan 2007).
Felipe et al (2008) attribute their findings largely to India's unfavourable institutional investment climate, and to China's bureaucratic push towards wasteful and inefficient investment. SOEs' bias towards wanton and inefficient expansion of investment, in particular, appears to constitute a major weakness of China's economic system. In our view, however, it is also important to see this issue in another perspective. Following Gabriele and Schettino 2008, we introduce the term "socialistic". Assume, as a mental experiment, a theoretical continuum of conceivable mixed socioeconomic systems, where on one hand there is a pure free-market, private-property based model of classical capitalism, and on the other hand a fully publicly-owned, centrally-planned socialist model. In this theoretical framework, the term "socialistic" indicates the property of being characterized by crucial systemic features in the domain of ownership, class, and other social relations of production and exchange which are relevant enough to position a specific socioeconomic formation rather strongly towards the socialist side.

Our reasoning is crucially based on a proposition which we consider a relatively self-evident stylized fact, but which by its very nature cannot be demonstrated formally. The important differences in the patterns of accumulation and technical change found in the two Asian giants are in turn the product of another key difference, which is stemming from the very structural nature of their respective socioeconomic formations. Simply put, in India, but not in China, there is a fullfledged capitalist bourgeoisie structured and organized as the dominant class[18] (see, for instance, Tsai 2008). Thus, China can be considered as one of the two presently existing members of a very small club that of a market-socialist or "socialistic" countries. India, conversely, is a "normal" capitalistic country.

A very important corollary of this crucial systemic difference is that the share of surplus which finances the bourgeoisie's conspicuous consumption in "normal" capitalistic countries is virtually non-existing (or more precisely, carries a much lesser macroeconomic and strategic weight) in China, and almost all the profits are reinvested.

In a capitalistic economy, the shadow price of potentially investible financial resources in the framework of a long-term social welfare function to be maximized by policy- makers is likely to be lower than private capitalists' implicit discount rate. Therefore, taking for given the wage rate and hence workers' consumption, there would be room left for other investment projects, which would imply a relatively low but still positive rate of profit .Thus, it is usually the case under "normal" circumstances that the actual share of invested surplus in a capitalistic economy is lower than the one which would be optimal from a long-term social welfare

viewpoint[24] (See Appendix).
What happens, conversely, in an economy that is "socialistic", even if only in a weak sense, such as China, where the state is strong enough to effectively command (via direct appropriation and/or via institutional, administrative, legal, and informal mechanisms) the allocation of a major share of the surplus? Ceteris paribus, a country with such "socialistic" characteristics should invest a share of the surplus higher than that of a capitalist country. It is reasonable to argue that this is in fact the case in China - largely because a large share of total profits is earned by SOEs, which are mandated by the state to pursue a number of objectives different from profit maximization, among them investment expansion.
According to our view, therefore, a socialistic society can exhibit a lower marginal productivity[26] of investment than an otherwise similar capitalist one, and still exhibit an overall superior behaviour with respect to the determination of both the quantity and the quality of national investment.[27] Whether this is in fact the case or not depends on the specific characteristics of the institutional framework shaping investment decision in a concrete socialistic economy, and can only be analyzed empirically on the basis of available data. Going back to the China-India comparison, it is known that the share of surplus that is plowed back to investment (which could also be called the investment/surplus ratio) is higher in China than in India. How much of China's additional (with respect to those which would be channelled towards capital accumulation in India, or another "normal" capitalist country) investment resources are rightly earmarked towards socially profitable projects - resulting in a lower marginal and average productivity of investment, but in a better long-term allocation of resources - and how much are totally or partially wasted ?
A related but different question is as follows. The recent decision to let SOEs start paying a significant (even if still very small) share of their profits as dividend to the state is to be welcome. The destination of these dividends is still not very clearly defined, as there would be good economic and social reason both to earmark them to social consumption and investment (e.g., public health care and education), but also to keep prioritizing investment in infrastructure, key high-tech sectors, and R&D. Given the suboptimal state of China's basic public services, and the very long-term unsustainability of an already very high and permanently rising investment rate, it is plain that a high degree of the priority in the short term should be accorded to enhance social public consumption and investment.

In the long term, however, assuming a stable and sustainable rate of accumulation is achieved, a more complex issue arises.

For any modern socioeconomic formation, it is clear that the only way out of the putative Marxian(actually Smithian) law of tendentially declining profit rates is not to slow down
accumulation per se, but to shift progressively more and more resources towards the development of high-tech and highly productive sectors[29] and towards R&D and S&T activities in particular, striving to accelerate the rate of technical progress and to improve its nature. Actually, the pattern of technical progress should be made less and less Marx-biased, capital consuming in nature, and become increasingly Hicksneutral,

or even capital-saving. Such a major drive towards the quantitative and qualitative improvement of technical change patterns must be pursued, at least in part, independently from a key price-based signal such as the expected market-measured profitability of individual investment projects, in a market-compatible framework based on a modern and advanced form of planning. We refer to a form of resources allocation where a significant share of aggregate investment is allocated according to shadow prices based on a long term socially-oriented planning framework. This framework should internalize to the maximum possible extent those needs and externalities which do not stem from the price structure emerging spontaneously from the market - i.e. the "real" long-term social value of education, health, the environment, R&D itself, etc. An important component of this overall planning framework might be an embodied mechanism to shape in a dynamically optimal fashion the evolution of the price structure itself.

3.3. Opportunities and Challenges: from NSI to POLIS?

Since the late 1990s, the Chinese Government has approved a number of crucial strategic decisions to build up a world-class National Innovation System, seen as " a networking system composed of institutions involved in knowledge innovation and technology innovation (which)… includes the following: knowledge innovation system netted with the state research institutions and key universities; technology innovation and technology application system with industrial enterprises; knowledge dissemination system with schools and universities. In 1998 the government instructed the Chinese Academy of Sciences (CAS) - a vast network of research institutes that are presently undergoing feverish expansion and reorganization - to initiate the Pilot Project of Knowledge Innovation Program (KIP)" (CAS 2008). An action plan was carried out for rejuvenating education in the 21st century, in addition to a national meeting on technology innovation and a working conference on basic science research, in order to further enhance the reform of the scientific research system. Plans are also drawn to open a second-board stock exchange in the securities market, similar to the American Nasdaq. The KIP piloted at CAS is a major component of the National Innovation System (see CAS 2008).

In January 2006 China launched the "National Medium- and Long-Term Program for Scientific and Technological Development" (2006-2020), commonly known as the 15-year Plan for science and technology. The Plan's long-term goal is to allow China to become a pre-eminent global economic and technological power, relying on "independent, indigenous innovation":[31] "By the end of 2020, we should establish an improved scientific and technological innovation system. . . We will strive to leapfrog the development of China's information science and technology and to acquire core technologies with proprietary intellectual property rights in the IT sector."(Quoted in AeA 2007).

Not all the details of the plan were made public, but its main tenets are clear. China is foreseen to raise R&D spending from the current 1.4 percent of its economic output to 2 percent by 2010 and 2.5 percent by 2020:"these commitments would put Chinese R&D investments above $100 billion annually, placing it in the same league as Japan and the United States (RTM 2007). Acknowledging that China's high-tech industry is growing fast but is still largely dominated by multinational companies and centred on low-value-added, labor-intensive manufacturing, "the 15 Year Plan intends to change that equation by investing heavily in such cutting-edge areas as nanotechnology and biotechnology to spawn indigenous innovation." (RTM 2007).

Table 5 The 15-year Plan's 12 priority sectors

Advanced Storage Technologies
Alternative and Renewable Energies
Biotechnology/Genetics
Electronic Components
Environmental Technologies
Integrated Circuits/Semiconductors
Manned Space Exploration
Materials Technology
Nanotechnology
Network and Communication Technologies
Optical and Biological Computing
Software and Related Services

Source: AeA 2007

According to American Electronics Association (AeA), which carried out a synthetic assessment of the plan in 2007, (AeA 2007), the Plan's goals are ambitious, but not unrealistic. China has a leadership mainly composed by engineers, who are in a favourable position to understand the nature and the strategic centrality of research and technology, and has already built up remarkable elements of strength in the S&T and R&D area. For instance, it has being pouring huge societal investments into higher education and research (state financing for higher education more than doubled in 1998-2003, reaching over USD10bn by the end of that period; China's number of researchers increased by almost 80% in 1995-2004, and is now second only to the US). Large SOEs are also investing heavily in technological upgrading and human capital formation, and there are a number of start-up innovative firms, some of them already established in international markets (such as Lenovo, Haier, and Huawei), and others active in crucial areas such as the provision of Internet services for the domestic market.

Yet, China also faces a number of challenges. Its high-tech industries are growing extremely fast, but they are mostly owned by foreign TNCs and still usually concentrated on low value-added stages in the value chain. In this respect, AeA (2007) quotes Daniel Rosen, a senior researcher in the Institute for International Economics, who half-jokingly remarked: “China’s high-tech exports turn out not to be so very high tech - nor, indeed, very Chinese.” Another key area of concern is constituted by weak IPRs protection - although the AeA rightly notes that the Plan acknowledges that China's own development interests are already shifting in favour of strengthening the IPR protection regime, and calls for action in this domain.
AeA (2007) argues that it is also urgent to take decisive measures to reform capital markets, encourage risk taking, and let ideas flow more freely, to stimulate truly innovative thinking and research. To our view, many of these challenges are in fact crucial - a significant exception being, probably, capital market reforms.

However, it is not straightforward that the remedies should always go in the direction of following the US model (as AeA appears to suggest), taking into account the strong arguments in favour of fostering a smooth reform path towards a specifically Chinese NSI consistent with the country's history and its market-socialist socioeconomic system (see, for instance Liu and White (2001), Keun Lee (2006)).

Finally, it is important to locate China's 15-year S&T Plan in the framework of the worldwide scenario shaped by the converging trends of key frontier technologies. As the APEC (2005) workshop on this topic has made clear, the convergence of information technology, biotechnology and nanotechnology (the so-called super convergence) might be the most significant technological event of the 21st century (see Khan 2005). The process of convergence is already underway. All the major national and regional players including USA, EU and Japan have already taken significant steps in order to maintain and gain further advantage in these technologies. China is a latecomer.

What can China do in order to be in the same league as the three major players mentioned above? Taking into account the challenges posed by a very competitive international environment where the other major players still hold a significant advantage, China can achieve super convergence only through the creation of a selfsustaining innovation system that can move forward over time, This paramount strategic goal must be properly seen as the logical evolution of the present S&T strategy, basically centered around perfecting China's NSI, towards a qualitatively superior, self-propelling innovation system. The 15-year Plan, if successful, will complete the catch up process by 2020. Between 2020 and 2050, the strategic goal should be to build up autonomously advanced technological capabilities in the three crucial areas, with a view towards moving towards super convergence. Regional cooperation with Japan, Korea and Taiwan can play an important role in this strategy. Ultimately, a Pan-Asian regional innovation network including India and the ASEAN countries might also be established. China's National Development and Reform Commission (NDRC) can start the process of national capacity building and regional cooperation by supporting key strategic ventures. Increasing the number of competent staff in the areas of planning for high technology development should be given serious consideration.

In Khan (2008a,c, 2004a, 2002,1998) the overall planning framework is presented as part of a system-wide effort to create a positive feedback loop for innovation, which is at the same time distributionally progressive, equitable,and environmentally sustainable. The term used by Khan to refer to such a mechanism is that of nonlinear positive feed back innovation system, or POLIS.A simple model of complexity is presented at the end of this sub-section. A more complex model is given in Appendix 3).The POLIS framework can be applied through quantitative economy-wide modeling techniques, in order to analyze the challenges for transition from now to 2020 and then from 2020 to 2050.

The POLIS approach is based on a somewhat novel theory of innovation in the

economy wide setting. Its first and most important feature is that the analysis of a POLIS can be thought of as part of the institutional turn in economic theory. However, in contrast with much institutional literature, its propositions can also be expressed in a formal language, through models that can be estimated quantitatively for both rigorous, empirical scientific testing and for policy making purposes. The starting point of the POLIS theory is the creative destruction process at the firm and industry level. However, an extension to an economy-wide setting requires the explicit theorization of the role of the state as well as an interacting nonlinear market process. The direction in which the theory leads is a complex interaction between state policies and market processes that influence the decisions taken by specific firms in particular areas of innovative activities. The key concept that is developed in this context can be called a Managed Creative Destruction (MCD) process. In a national (or regional) MCD, the creative destruction process characterizing innovation is structured more consciously by the state (or the states in a particular region). It can be argued that China is now going through this process. Following Schumpeter, we assume that innovation in specific firms can have economy-wide effects. As models based on this approach have multiple equilibria, the concept of a positive feedback loop innovation system or POLIS is formalized by picking an appropriate sequence of equilibria over time. It can be also shown that POLIS has empirical relevance by applying the formal model to an actual economy. Ultimately, technological transformation — in particular the creation of a positive feedback loop innovation system - is what makes the difference between sustained growth and gradual or sudden decline.
In addition to the system wide approach to innovation over time, the POLIS theory offers two other distinct advantages. One is the linkage between micro and meso or macro levels. One can start with firm level data on innovation activities and link these to sectoral and intersectoral information flows. In this way, what happens at the firm level can be seen from a larger, economy wide perspective. At the same time, the impact of firm level activities on overall level and pace of innovation can also be ascertained qualitatively and quantitatively.

The third aspect of POLIS is distributional. Since the complex system dynamics of POLIS is holistic, it integrates production with distribution. Thus the distribution of value added in production at both the factorial and household levels can be formulated as part of a general equilibrium (or, under circumstances of internal or external shocks, disequilibrium) frame work. Given the levels and distribution of income among households, the consumption patterns and effective demand feedback mechanisms complete the formulation of a system wide model.

While acknowledging the impressive progress achieved so far, a comprehensive recent OECD study on China's innovation system (OECD 2007) concluded with a sobering warning: "China needs a better return on its fast-rising investments in research and development (R&D) and higher education if it is to meet its goal of becoming an 'innovation-oriented' economy by 2020…China still has a long way to go to build a modern, high-performance national innovation system.". This statement is realistic, as it stresses the uncertainties of the future without

underestimating Chinese government's firm strategic determination to achieve the 15-year Plan's goals. China's leadership seems to be fully aware of the centrality of science and technology, not only for economic growth, but also with respect to other crucial challenges, such as the ultimate environmental sustainability of its market socialist development model and for the sake of enhancing China's relative place among the world leading nations. Consistent with this goal, it has been earmarking towards research and the broader S&T sector an increasing share of China's fastgrowing
GDP. As a result, China has now achieved a substantial critical mass in the area of research and innovation, second only (according to some estimates) to that of the US, and growing four times faster than that of any of the major world technological leaders, among which there are signs that the enthusiasm for everincreasing
investment in R&D might be someway declining, both in the public and the private sectors. There is by now plenty of evidence showing that the over the last decade China has witnessed major efficiency-enhancing institutional and organizational changes, including in the area of property rights, a massive accumulation of human capital, and a very sustained rate of scientific and technical progress. Labor productivity has been rising fast, and a major part of the improvement is likely to be due to the aforementioned factors, even taking into account China's extraordinary rate of non-human capital accumulation. R&D input indicators and output indicators such as patents and scientific papers have been rising fast. Yet, a closer look shows that China is doing an excellent job at absorbing, adapting and developing existing technologies, but is still lagging significantly behind world technological leaders in terms of capability to generate state-of-the-art, world-class innovation proper, as is shown for instance by data on basic research and inventions patents
.

With respect to state industry, the assessment of available evidence on SOEs' performance is more complex. Most sources indicate that, until the end of the past century, SOEs had been absorbing a major share of investment funds while exhibiting efficiency and profitability levels lower than enterprises belonging to other forms of ownership. Yet, their propensity to innovate (not always in an effective way) was high, and their productivity climbed dramatically, especially during the late 1990s. Latest available evidence appears to show that, during the present decade, the policy of concentrating huge resources on a small number of large and advanced SOEs, while letting smaller and less efficient state enterprises to fend more or less for themselves (recurring increasingly to extreme measures such as closures or ownership changes) has begun to bring significant qualitative fruit, as testified by core SOEs' increasing profitability and international competitiveness and by the embryonic emergence of some world-class state-owned TNCs. Both SOEs and large industrial enterprises operating in China under different forms of ownership - such as joint ventures and private (national and foreign) firms - manifest a very strong willingness to innovate, at a time when their counterparts in the US and - to a lesser extent - other OECD countries appear to show a sort of innovation fatigue.

The economic sustainability of China's historically unprecedented S&T effort

does not presently appear an issue, at least in the short-to-medium term, taking into account the leadership's determination in prioritizing the S&T sector and the resilience of China's GDP growth rates, even in presence of diverse unfavorable exogenous phenomena such as the Sichuan earthquake and the overall slowdown in the international economy triggered by the US subprime crisis.
As a result, China's NSI is undergoing major quantitative and qualitative changes. The latter are those which bear the most crucial weight. The main features of the 15-year plan appear to show that the basic tenets of the two-pronged S&T strategy outlined in Gabriele (1992) still hold. On one hand, the relationship between most R&D activities and the market is becoming closer and closer. Most of the R&D is already being carried out inside the enterprise sector, while universities and research institutes are intensifying their contacts with firms, and generating themselves start-up ventures to develop, produce and commercialize their innovations. The IPR protection system, in particular, is evolving towards a higher level of protection, partly to respect China's WTO obligations, but mainly to suit the present development stage, characterized by an increasing degree of commercialization of the bulk of technological knowledge (essentially, the one stemming from applied research and development activities). On the other hand, in order to tackle the crucial weaknesses mentioned above, vast financial, human and institutional resources are being channeled towards a long-term basic research endeavor, concentrating on a limited number of strategic high-tech sectors. This major effort is articulated institutionally in a decentralized fashion, yet operates in a broadly consistent organizational and financial framework set up as a key component of China's specific form of strategic development planning.

The challenge, at the present stage, is to engineer in a relative short period (10-15 years) a decisive qualitative leap in China's NSI, developing a systemic ability to generate world-class indigenous innovations. In addition to generating technical progress, China's development strategy shall also take into account the challenge of establishing a model of innovation compatible with an equitable pattern of income distribution and environmental sustainability, thereby paving the way to the eventual evolution towards a higher and more developed form of socialism. This is the expressed aim of the Chinese leadership, and also enjoys considerable popular support.

However, the conventional NSI approach does not include a set of social and other informational requirements which are crucial to policy makers in order to steer successfully such a complex transition. Therefore, there is a need for more advanced analytical and planning tools. In this respect, we briefly refer to one particular approach, exemplified by the models introduced by Khan (1998, 2002, 2004a,b,c and 2008a,b,c) within the context of nonlinear positive feed back innovation systems or POLIS. POLIS can be thought as a generalization of NSI that embodies distributional, ecological and other issues relating to socio-economic (and even political) development. Therefore, POLIS-type models are sensitive to many of the abovementioned concerns relevant to the strategy of development in China. POLIS-type models can be used to chart strategically the market socialist course, as their internal logic is also consistent with China's "walking-on-two-legs" catch up strategy. Actually, this strategy aims at embodying world-class best practices from technological world leaders and successful late industrializers, but is also uniquely Chinese in at least two crucial aspects. The first is China's sheer size, which has allowed her to leapfrog to rank 2 worldwide in terms of the absolute quantitative magnitude of its NSI, at a stage when it still lags far behind all technological leaders

3.4 A 'Simple' Non-linear Model of Complexity and POLIS Motivated by the Chinese Experience

In order to give the reader some idea of the problem of formalizing complex technological systems motivated by the above case study of China in particular, we summarize here the basic structure of a 'simple' non-linear model embodying distinct technological systems which can be applied to analyze the technological trajectories in countries like China. At any single point in time, the model can be presented as a Social Accounting Matrix (SAM) representation of the socio-economic system. The key distinction here is the explicitly non-linear nature of the economy-wide functional relationships. The key theorem shows the existence of multiple equilibria. Some further considerations of complexity and increasing returns show that multiple equilibria are indeed the natural outcomes in such models. Thus, there would seem to be some role for domestic policy in guiding the economy to a particular equilibrium among many.

The virtue of an economy-wide approach to technology systems is the embodiment of various inter-sectoral linkages. In a SAM, such linkages are mappings from one set of accounts to another. In terms of technology systems, the production activities can be broken down into a production (sub-) system and a set of innovative activities. In practice, this presents considerable difficulties of classification and empirical estimation.

One major component of the entire innovation system is, of course, the expenditures on R&D. In the SAM for Korea used here, this can appear either as an aggregate expenditure along the column labeled R&D, or as a set of disaggregated expenditures.[1] In the latter case these may be specified according to productive activities (e.g., construction, electrical equipment, etc.) or by institutions (e.g., private R&D expenditures, government R&D expenditures, etc.). It should be emphasized that the dynamic effects of R&D on the economy can be captured only in a series of such SAMs over time. This approach is still at the conceptual stage, but appears to be quite appealing. One can contrast the possible policy experiments that can be undertaken within such a framework with the apparently ad hoc science and technology policies in many developing countries. In particular, the impact over time of a POLIS can be traced by building and maintaining such SAMs.

Choice of new technology in a developing country is affected by research and development in at least three different ways. Such a country can attempt to develop new technology through R&D, as mentioned previously. This ultimately requires a positive feedback loop innovation system in order to be self-sustaining. Another alternative is to adapt existing technology. This too requires a production system geared towards innovation in a limited way. A third alternative is to import technology or to acquire it through attracting foreign direct investment. In practice, all these different forms may be combined. The abstract model embodies all these different possibilities. However, the first option requires, among other things, a presence of multiple equilibria. In a unique equilibrium world the competitive equilibrium (under the assumption of complete markets) will always be the most efficient one. The presence of increasing returns usually destroys such competitive conditions.

We begin with a number of productive activities reflecting the existing technological structure. These activities are defined on the input-output subspace of the general and abstract mathematical space X. In addition to the values of inputs and outputs, points in this space could also represent household and other institutional income and expenditure accounts. We also incorporate the possibility of R&D as a separate productive activity. Formally, it is always possible to break R&D down into as many finite components as we want. The key relationship in this context is that between the endogenous accounts (usually, production activities and technologies, factors and households) and the exogenous ones. It is this relationship that is posited to be non-linear and this together with some assumptions on the relevant mathematical space can lead to the existence of multiple equilibria.

Although the existence theorems for these multisectoral models provide some structure for the equilibria as sequences of fixed points in the socio-economic structure with evolving technology systems, it is not specified a priori which equilibrium will be reached. The problem of equilibrium selection thus remains open. The idea behind a POLIS can now be stated somewhat more formally. It is to reach a sequence of equilibria so that in the non-linear models of the entire economy the maximal fixed points that are attainable are in fact reached through a combination of market forces and policy maneuvers over time. It is also to be understood that path-dependence of technology would rule out certain equilibria in the future. Thus initial choices of technologies can matter crucially at times.

The Model on a Lattice

Define X as a vector lattice over a subring M of the real field R.Let $x_+ = \{x \mid x \in X, x \geq 0\}$

A non-linear mapping N is defined such that $N : X_+ \to X_+, N_0 = 0$. Given a vector of exogenous variables d, the following non-linear mapping describes a simultaneous non-linear equations model of an economy, E:

$$x = Nx + d \qquad (1)$$

for a given $d \in X_+$.

This non-linear system represents a socio-economic system of the type described previously. In order to specify the model further, the following assumptions are necessary.

1. X is order complete
2. N is an isotone mapping
3. $\exists \hat{x} \in$ such that $\hat{x} \geq N\hat{x} + d$

In terms of the economics of the model, the non-linear mapping from the space of inputs to the space of the outputs allows for non-constant returns to scale and technical progress over time. The 3 assumptions are minimally necessary for the existence of equilibrium. Assumption 3, in particular ensures that there is some level of output vector which can be produced given the technical production conditions and demand structure.

Existence of Multiple Equilibria:

Theorem: Under the assumptions 1 - 3, there exists $x^* \in X_+$ so that x^* is a solution of

$x = Nx + d$

Proof: Consider the interval $[0, x] = \{\hat{x} \mid \hat{x} \in X_+, 0 \leq \hat{x} \leq x\}$ where $\hat{x}$ is defined as in assumption 3. Take a mapping F.

$F : x \in X_+ \rightarrow Nx + d$

F is isotone and maps $[0, x]$ into itself.

Define a set $D \equiv \{x | x \in [0, x], x \geq Fx\}$.

By assumption 3, D is non-empty.

We now show $x^* \equiv \inf D$ is a solution to $x = Nx + d$. $x^* \equiv \inf D$; therefore $x^* \leq x, \forall x \in D$. F is isotone; therefore $Fx^* \leq Fx \leq x$ for each $x \in D$ implying.

$Fx^* \leq x^*$

From (2) we have $F(Fx^*) \leq Fx^*$. Thus $Fx^* \in D$; hence $x^* \equiv \inf D \leq Fx^*$ so, $Fx^* \leq x^* \leq Fx^*$. Therefore $x^* = Fx^*$.

This is an application of Tarski's and Birkhoff's theorem. The key feature to note here is that the equilibrium is not necessarily unique. It should also be noted that under additional assumptions on space X and the mapping N the computation of a fixed point can be done by standard methods (e.g. Ortega and Rheinboldt).

Needless to say, any formalization of a complex system leaves out certain features. For example, the political features of POLIS are captured only indirectly and inferentially in the above model. But at least the ecological and distributive features can be captured by constructing the appropriate environmentally-sensitive SAMs and applying the model over time for a country like China. What the above verbal argument and formal exercise suggest is the feasibility of an alternative developmental model that builds upon some of the insights of the Asian success stories like China but also can take some necessary steps to face the ecological and political economic challenges of the 21st century.

4. Conclusions---Beyond the China Model: Making Globalization Work towards Sustainable Industrialization and Development

The critical discussion of both the East Asian development experience and the Chinese innovation system leads to two conclusions among other things. The first is that these were exceptional cases even under the first phase of the US empire and will be impossible to replicate under the current rules of the game instituted by the US and other developed countries. Therefore, the current rules of globalization must change. The second conclusion is that even if these rules change and some other countries can move forward on the path of industrialization, the older 20th century modes of industrialization based on fossil fuel based technology will not be sustainable. As Khan(2009, forthcoming) demonstrates, even for China the current strategy of development and patterns of energy consumption are unsustainable. In this particular work reported in Khan(2009, forthcoming) , I have sketched the energy dilemma for China in this century. As long as the current geopolitical situation persists, the pursuit of present development strategy of China will further increase its energy dependence. For both political and economic reasons, China needs to rethink its development strategy. I have sketched such an alternative strategy that relies much less on fossil fuels and emphasizes regional cooperation.In the present essay, I have shown how the NSI of China can begin to move towards an ecologically sustainable POLIS. This POLIS strategy will ultimately lead to a sustainable economy based on growth with equity. A transition to a non-fossil fuel based knowledge and information economy will also be easier to effect under the proposed strategy.

However, time is of the essence. Given the path dependence of development unless strategic disengagement from the existing path followed by a strategic engagement with the alternative strategy is begun within the next five years, it may well be too late. The stakes are indeed very high. A more detailed strategy paper based on the key ideas from the alternative strategy outlined here with concrete quantitative scenarios and feasibility studies along the lines of models sketched in the Appendix (and other, more detailed models) will go some distance towards giving the appropriate analytical foundations for the policymakers. The preliminary results confirm the predictions regarding fossil fuel-based energy shortage and lead towards a serious consideration of alternative energy sources. Achieving the twin goals of energy security and ecological balance are challenging but not impossible for China. Serious policy research can be used effectively if there is the political will to do so. The goal of regional cooperation is also achievable if patient negotiations in good faith can start in earnest. In particular, cooperation with other Asian economies, particularly Japan, Indonesia, Vietnam, and India will be crucial. This chapter has sketched out the complexities of cooperation and conflict between China and Japan. Future work will address the problems of Regional cooperation for China in the East, South, and South Asian context as well as in the context of Africa and Latin America.

Khan et. al.(forthcoming) shows this for the BRICS as a group. This paper investigates the relation between rapid economic growth and environmental degradation in the BRIC economies. It utilizes environmental, macroeconomic and financial variables coupled with Kyoto Protocol indicators based on panel data from 1992 to 2004.In keepimg with the goal of examining long run sustainability, the long-run equilibrium relationship between economic growth and energy consumption is examined. *Feasible general least squares* procedure (FGLS) is employed to estimate the environmental degradation caused by increases in energy consumption. *Pooled regression analysis* is used to estimate the relationship between energy consumption and growth variables. The impact of excessive economic growth rates on energy consumption levels is studied by means of *threshold pooled ordinary least squares* (POLS) method. Moreover, this analysis takes into account the legitimate econometric criticism of the Environmental Kuznets Curve highlighted by Stern (2004). The findings reveal that higher energy consumption leads to increased CO_2 emissions in the countries under consideration.It is also found that rapid economic growth further inflates energy consumption levels in the emerging BRIC economies. The results of cointegration analyses also confirm these findings. Finally, the inclusion of the US and Japan as the world's largest energy consumers does not significantly alter the results of our study.

The implications of the study of China's energy and innovation systems and of the long run growth implications of the BRIC economies for environment are quite clear. The crucial question is: what kind of transformations in the global economic environment and development discourse will influence the policies of these economies in the right direction. A related question is: how can the larger economies of the world play an enabling rather than a predatory role in furthering sustainable industrialization and development in all the countries including the LDCs?

Appendix 1: Growth impacts of the industrial and non-industrial sectors – a simple SAM-based Model

Fixed price modelling in a SAM-based framework

In this section of the appendix, the social accounting matrix is presented as a data-gathering framework as well as an analytical tool for studying the effects of the energy sectors on growth. Appendix 2 presents the methodology for estimating the impact of growth generated by both the industrial and non-industrial sectors on poverty alleviation. The origins of social accounting can be traced as far back as Gregory King's efforts in 1681, but more recent work stems from the attempts by Richard Stone, Graham Pyatt, Erik Thorbecke, and others.[13]

In the methodological framework of this study, the SAM is used for mapping production and distribution at the economy-wide level. In this section, first a general SAM is described. Then it is shown how the method for studying the effect of growth within this framework follows logically from its structure. The model used is a simple version of a class of SAM-based general equilibrium models.[14] It summarizes succinctly the interdependence between productive activities, factor shares, household income distribution, balance of payments, capital accounts, and so on, for the economy as a whole at a point in time. Given the technical conditions of production, the value added is distributed to the factors in a determinate fashion. The value added accrued by the factors is further received by households according to their ownership of assets and the prevailing wage structure. In the matrix form the SAM consists of rows and columns representing receipts and expenditures, respectively. As an accounting constraint receipts must equal expenditures.

As is elaborated further in Khan and Thorbecke (1988), the SAM framework can be used to depict a set of linear relationships in a fixed coefficient model. For deciding the question of determination, the accounts need to be divided into exogenous and endogenous ones. For instance, in the China SAM, there are three endogenous accounts.

INSERT TABLE A1 ABOUT HERE

These are factors, households and production activities, leaving the government, capital and the rest of the world accounts as exogenous.[15]

Looking at Table 7A2, which represents a SAM, we can see immediately that

$$y = n + x \tag{1}$$

$$y = 1 + t \tag{2}$$

[13] For a description of SAM as a data-gathering device, see Pyatt and Thorbecke (1976). Khan (1997) also has a chapter on this alone.

[14] In Walrasian general equilibrium models the flexible price vector determines the equilibrium. In a Keynesian (dis)equilibrium model in the short-run the quantities vary while the price vector remains fixed.

[15] See Khan and Thorbecke (1988: ch. II) for more theoretical details and empirical examples. The presentations here follow the cited work closely.

Now if we divide the entries in the matrix T_{nn} by the corresponding total income (that is, y_n), we can define a corresponding matrix of average expenditure propensities. Let us call this matrix A. We now have:

$$y = n + x = Ay + x \tag{3}$$

$$y = (1 - A)^{-1} x = Mx \tag{4}$$

M has been called the matrix of accounting multipliers by Thorbecke, for these multipliers, when computed, can account for the results (for example, income, consumption, and so on) obtained in the SAM without explaining the process that led to them. Let us now partition the matrix A in the following way (Khan and Thorbecke).

$$A = \begin{bmatrix} 0 & 0 & A_{13} \\ A_{21} & A_{22} & 0 \\ 0 & A_{32} & A_{33} \end{bmatrix} \tag{5}$$

Given the accounts factors, household and the production activities, now we see that the income levels of these accounts (call them y_1, y_2, y_3, respectively) are determined as functions of the exogenous demand of all other accounts. In this respect, what we have is a reduced-form model which can be consistent with a number of structural forms. This is quite satisfactory as far as tracing the effects of a certain injection in the economy is concerned or for prediction purposes when the structural coefficients are more or less unchanged.

INSERT TABLE A2 ABOUT HERE

One limitation of the accounting multiplier matrix M as derived in equation (4) is that it implies unitary expenditure elasticities (the prevailing average expenditure propensities in A are assumed to apply to any incremental injection). A more realistic alternative is to specify a matrix of marginal expenditure propensities (C_n below) corresponding to the observed income and expenditure elasticities of the different agents, under the assumption that prices remain fixed. The C_n matrix can be partitioned in the same way as the A matrix above. The most important difference between the two partitioned matrices is that $C_{32} \neq A_{32}$. Expressing the changes in income (dy) resulting from changes in injections (dx), one obtains

$$\mathrm{d}\, y_n = C_n \,\mathrm{d}\, y_n + \mathrm{d}\, x \tag{6}$$

$$= (I - C_n)^{-1} \,\mathrm{d}\, x = M_c \,\mathrm{d}\, x \tag{7}$$

M_c has been called a fixed price multiplier matrix and its advantage is that it allows any nonnegative income and expenditure elasticities to be reflected in M_c. In particular, in exploring the macroeconomic effects of exogenous changes in the output of different product-cum-technologies on other macroeconomic variables, it would be very unrealistic to assume that consumers react to any given proportional change in their incomes by increasing expenditures on the different commodities by exactly that same proportion (that is, assuming that the income elasticities of demand of the various socioeconomic household groups for the various commodities were all unity). Since the expenditure (income) elasticity is equal to the ratio of the marginal expenditure propensity (MEP_i) to the average expenditure propensity (AEP_i) for any given good i, it follows that the marginal expenditure propensity can be readily obtained once the expenditure elasticity and the average expenditure propensities are known, that is,

$$y_i = MEP_i/AEP_i \tag{8}$$

$$MEP_i = y_i \, AEP_i \tag{9}$$

and

$$\sum_i MEP_i = 1 \tag{10}$$

Thus, given the matrix A_{32} of average expenditure propensities, and the corresponding expenditure elasticities of demand, y_i the corresponding marginal expenditure propensities matrix C_{32} could easily be derived.[16]

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[16] See Khan and Thorbecke (1988) for some examples. See also Pyatt and Round (1979: 861).

Appendix 2: Innovating and Other (including Energy) sectors, growth, distribution and poverty

Multiplier decomposition, growth and poverty alleviation sensitivity

Since poverty in the present context is measured by identifying a poverty line in monetary terms, incomes of the various household groups are the crucial variables. In particular, sectoral growth generated by the energy sectors must be linked to incomes of the various households in order to determine the exact extent of the alleviation of poverty through growth. The exact effect of income growth on poverty, of course, depends on the sensitivity of the adopted poverty measure to income. In this paper the Foster-Greer-Thorbecke (FGT 1984) P_α class of additively decomposable poverty measure is selected for this purpose. For $\alpha = 0, 1, n$ this measure becomes the headcount ratio, the poverty gap and a distributionally sensitive measure that gives specific weights to each poor person's shortfall, respectively.
If we apply Kakwani's (1993) decomposition to the P_α measure for specific sectors and households i and j respectively, the change in $P_{\alpha ij}$ can be written as follows:

$$\mathrm{d}\,P_{\alpha ij} = \frac{\partial P_{\alpha ij}}{\partial \bar{y}_i} + \sum_{k=1} \frac{\partial P_{\alpha ij}}{\partial \theta_{ijk}} \mathrm{d}\,\theta_{ijk} \tag{11}$$

Here $P_{\alpha ij}$ is the FGT P_α measure connecting sector j to household group i, y_i is the mean per-capita income of household group i, and θ_{ijk} is the income distribution parameter. Under the unrealistic but simplifying assumption of distributional neutrality:

$$\frac{\mathrm{d}\,P_{\alpha ij}}{P_{\alpha ij}} = \eta_{\alpha i}\left(\frac{\mathrm{d}\,\bar{y}_i}{\bar{y}_i}\right) \tag{12}$$

where $\eta_{\alpha i}$ is the elasticity of P_{ij} with respect to the mean per capita income of each household group i resulting from an increase in the output of sector j. $\mathrm{d}\,\bar{y}_i$ on the right hand side is the change in mean per capita income of household group i. This can be written as (by considering the fixed price multiplier matrix)

$$\mathrm{d}y_c = m_{ij}\,\mathrm{d}x_j \tag{13}$$

where $\mathrm{d}x_j$ is the change in the output of sector j on a per capita basis for group j. We can now rewrite the average change in poverty measure as

$$\frac{\mathrm{d}\,P_{\alpha ij}}{P_{\alpha ij}} = \eta_{\alpha i} m_{ij}\left(\frac{\mathrm{d}\,x_j}{\bar{y}_i}\right) \tag{14}$$

By aggregating across the household groups we can arrive at the overall poverty alleviation effect

$$\frac{\mathrm{d}\,P_{\alpha j}}{P_{\alpha j}} = \sum_{i=1}^{m}\left(\frac{\mathrm{d}\,P_{\alpha ij}}{P_{\alpha ij}}\right)\left(\frac{\eta_i}{\eta}\right) = \sum_{i=1}^{m}\left(\frac{\mathrm{d}\,P_{\alpha ij}}{P_{\alpha ij}}\right)\left(\frac{P_{\alpha ij}}{P_{\alpha j}}\right) \tag{15}$$

Since we are considering a P_α measure

$$\frac{\mathrm{d}\,P_{\alpha j}}{P_{\alpha j}} = \sum_{i=1}^{m}\left(\frac{\mathrm{d}\,P_{\alpha ij}}{P_{\alpha ij}}\right)\left(\frac{\sum\left(\left(z-y_k\right)/z\right)^{\alpha}}{\sum\left(\left(z-y_1\right)/z\right)^{\alpha}}\right) \tag{16}$$

where q_i is the number of poor in the ith group and the total number of poor $q=\sum_{i=1}^{m} q_i$

Let $s_{\alpha i}$ be the poverty share of household group i (naturally $\sum_{i=1}^{m} s_{\alpha i}=1$)

$$s_{\alpha i} = \sum_{k=1}^{q_i}\left(\frac{z-y_k}{z}\right)^{\alpha} \Big/ \sum_{l=1}^{q}\left(\frac{z-y_l}{z}\right)^{\alpha} \tag{17}$$

We can further rewrite the expression for the average change in overall poverty alleviation.

$$\frac{\mathrm{d}\,P_{\alpha j}}{P_{\alpha j}} = \sum_{i=1}^{m}\left(\frac{\mathrm{d}\,P_{\alpha ji}}{P_{\alpha ij}}\right) s_{\alpha i} \tag{18}$$

Combining Equations 14 and 18, we now have

$$\frac{\mathrm{d}\,P_{\alpha j}}{P_{\alpha j}} = \sum s_{\alpha i}\eta_{\alpha i} m_{ij}\left(\frac{\mathrm{d}_{xj}}{\overline{y}_i}\right) \tag{19}$$

Thorbecke and Jung (1996) separate the income increase via the modified multiplier effect from the sensitivity of the poverty measure formally in Equation (19) by defining the following two entities:

- $m'_{\alpha ij} = s_{\alpha i} m_{ij}$ gives the modified multiplier effect in terms of income of a poor group.
- $q_{\alpha ij} = \eta_{\alpha i}(\mathrm{d}x_j / \overline{y}_i)$ represents the sensitivity of the poverty index to the change in income. I adopt their terminology and call this the poverty sensitivity effect.

But each multiplier m_{ij} can be further decomposed:

$$m_{ij} = \eta_j d_{ij} \tag{20}$$

where n_j gives the (closed loop) interdependency effects and d_{ij} the distributional effects of a change in demand for the product of sector j on household group i.
Thus

$$\frac{\mathrm{d}\,P_{\alpha j}}{P_{\alpha j}} = \sum^{m} m'_{\alpha ij} q_{\alpha ij} \tag{21}$$

$$= \sum_{i}^{m}\left(r_{\alpha ij}\right)\left(s_{\alpha ij}\,\mathrm{d}_{ij}\right)\left(q_{\alpha ij}\right) \tag{22}$$

The d_{ij} on the right hand side can be further decomposed by multiplicatively decomposing the total distributive effects. Given the structure of C_n matrix:
$D = D_3 D_2 D_1$ where $D_3 = (I - C_{22})^{-1}$; $D_2 = C_{21}C_{13}$, and $D_1 = (I - C_{33})^{-1}$
The particular element for each household i and sector j can be selected from these three matrices.
Thus the contribution of an increase in output of a particular sector i to poverty alleviation can be decomposed multiplicatively into its two components: (i) the contribution due to the change in mean income of the poor across all groups and (ii) the sensitivity of the particular poverty measure to this change in average income of the poor.

Appendix 3: The POLIS approach and a more complex illustrative model

Multiple Equilibria on Banach Space for a POLIS model:

In this section the results for multiple equilibria presented in the main text are extended to functionals on Banach Space. We can define the model presented in section 3.4 again for monotone iterations, this time on a non-empty subset of an ordered Banach space X. The mapping $f : X \rightarrow X$ is called compact if it is continuous and if $f(x)$ is relatively compact. The map f is called completely continuous if f is continuous and maps bounded subsets of X into compact sets. Let X be a non-empty subset of some ordered set Y. A fixed point x of a map $N : X \rightarrow X$ is called minimal (maximal) if every fixed point y of N in X satisfies
$x \le y (y \le x)$

Theorem: Let (E, P) be an ordered Banach space and let D be a subset of E. Suppose that $f : D \rightarrow E$ is an increasing map which is compact on every order interval in D. If there exist $y,\ \hat{y} \in D$ with $y \le \hat{y}$ such that $y \le f(y)$ and $f(\hat{y}) \le \hat{y}$, then f has a minimal fixed point x. Moreover, $x \le y$ and $x = \lim F^k(y)$. That is, the minimal fixed point can be computed iteratively by means of the iteration scheme

$$x_0 = y$$
$$x_{k+1} = f(x_k) \qquad k = 0,1,2,....$$

Moreover, the sequence (x_k) is increasing.

Proof: Since f is increasing, the hypotheses imply that f maps the order interval $[\bar{y}, y]$ into itself. Consequently, the sequence (x_k) is well-defined and, since it is contained in $f[\bar{y}, y]$, it is relatively compact. Hence it has at least one limit point. By induction, it is easily seen that the sequence (x_k) is increasing. This implies that it has exactly one limit point $\bar{x}$ and that the whole sequence converges to $\bar{x}$. Since f is continuous, $\bar{x}$ is a fixed point of f. If x is an arbitrary fixed point in D such that $x \ge \bar{y}$, then, by replacing y by x in the above argument, it follows that $\bar{x} \le x$. Hence $\bar{x}$ is the minimal fixed point of f in $(\bar{y} + P) \cap D$. It should be observed that we do not claim that there exists a minimal fixed point of f in D.

We can also show that if $F : x \in X_+ \rightarrow Nx + d$ is an intersecting compact map in a non-empty order interval $[x, \hat{x}]$ and $x \le Fx$ and $F\hat{x} \le \hat{x}$ then F has a minimal fixed point x^* and a maximal fixed point x^{**}. Moreover, $x^* = \lim F^k(x)$ and $x^{**} = \lim F^k(\hat{x})$. The first of the above sequences is increasing and the second is decreasing

References:

Accenture 2007, High-Performance IT: Research Results from China, in http://www.accenture.com/Global/Research_and_Insights/By_Role/HighPerformance_IT/CIOResearch/HPITChinaResearch.htm

Accenture 2008, High Performance IT 2008: There's No Substitute for Substitution, in http://www.accenture.com/Global/Research_and_Insights/By_Role/HighPerformance_IT/CIOResearch/HPIT2008.htm

APEC(2005), International Workshop on Emerging Technologies: The Challenges of Convergence", Bangkok, Dec.14-16,2005 http://www.apecforesight.org/emerging_tech/index.htm (last accessed June23,2008)

Altenburg T., Schmitz H., Stamm A., "Breakthrough China's and India's Transition from Production to Innovation", World Development, 2008, Vol.36

American Electronics Association (AeA), 2007, China's 15 Year Science and Technology Plan - What Does It Mean To Spawn "Indigenous Innovation?", AeA Competitiveness Series, Vol.14, in http://www.aeanet.org/publications/AeA_CS_China_15_Year_Plan.asp

Arora A., Ceccagnoli M., and , Wesley M. Cohen W., R&D and the patent premium, NBER Working Paper Series - National Bureau of Economic Research, 2003 January; (January)(9431)

Brécard D., Fougeyrollas A., Le Mouël P., , Lemiale L., , Zagamé P., Macro-economic consequences of European research policy: Prospects of the Nemesis model in the year 2030, Research Policy, Volume 35, Issue 7, September 2006, Pages 910-924

Camerer C., Loewenstein G., and Prelec D., 2005, "Neuroeconomics: How neuroscience can. inform economics,"Journal of Economic Literature, Vol. XLIII, March

Chang, H.-J. ed.(2007) Institutional Change and Economic Development, UNU press, Tokyo.

Chinaview 2007, China's SOEs to see profits surge 30% this year, in www.chinaview.cn 2007-12-18 16:47:07.

China.org.cn, 2007, by Chen Lin, December 12, MOF regulates SOE's dividends ratio to the government

China Academy of Sciences (CAS), 2008, Construction of China's National Innovation System, in
http://english.cas.ac.cn/eng2003/news/detailnewsb.asp?InfoNo=20966

China Daily 2007, June 5, SOE Dividends Should Benefit the Public

Chung O., 2007, China's phone makers in speed dial mode Asia Times nov 3 2007http://www.atimes.com/atimes/China_Business/IK03Cb01.html

Cline, William R. (1982). "Can the East Asian Export Model of Development Be Generalized?",*World Development*, Vol.10, no.2 pp.81-90.

Cochrane (2005), Commentary , Posted on ZDNet News: Apr 7, 2005, in

http://news.zdnet.com/2100-9589_22-5658944.html

David P.A., Hall B.H., and Toole A., 2000, , Is public R&D a complement or substitute for private R&D? A review of the econometric evidence
Research Policy, Volume 29, Issues 4-5, April 2000, Pages 497-529

Dahlman C.J., China and India: Emerging Technological Powers, 2007, . Issues in Science and Technology. Washington: Spring 2007. Vol. 23, Iss. 3

Dodson b., China SOEs Getting Lean and Mean
March 17th, 2008 | by This is China! |

Dyer G. and McGregor R., 2008, China's champions: Why state ownership is no longer proving a dead hand, Financial Times, March 16.

Ernst H., Industrial research as a source of important patents
Research Policy, Volume 27, Issue 1, May 1998, Pages 1-15

Felipe, J. (1999) 'Total factor Productivity growth in East Asia: A Critical Survey', Journal of Development Studies, 35(4): 1–41.

Felipe J. [c], Editha L. E., and Xiaoqin Fan E., 2008, The Diverging Patterns of Profitability, Investment and Growth of China and India During 1980–2003, World Development 36- 5, May.

Foley D.and T. Michl T.,, 1999, Growth and distribution, Harvard University Press, Cambridge, MA and London (1999).

Gabriele A ., 1993, Il ruolo delle imprese rurali nello sviluppo industriale cinese (The Role of Rural Enterprises in China's Industrial Development), Development/Sviluppo, 1993, University of Rome.

Gabriele A., 2002, S&T Policies and Technical Progress in China's Industry, Review of International Political Economy, Vol.9, No.2, Summer, 2002.

Gabriele, A and Schettino, F. (2008): *Market Socialism as a D Socioecionomic formation internal to the Modern Model of Production,* MPRA Paper No. 7942, posted 27. March 2008 / 11:02
Online at http://mpra.ub.uni-muenchen.de/7942/
Gabriele, A and H. A. Khan, 2010. China's NSI, Berlin: LAN Academic Publishers

Ghose A., Majid N., Ernst C., The Global Employment Challenge, ILO, 2008.

Goel R.K. and. Hsieh E.T., 2006, On coordinating environmental policy and technology policy, Journal of Policy Modelling, Volume 28, Issue 8, November 2006.

Guangzhou Hu, A., 2002, Ownership, Government R&D, Private R&D, and Productivity in Chinese Industry Journal of Comparative Economics
Volume 29, Issue 1, March 2001, Pages 136-157

Haiyan W., Yuanlong Z., Kaiyuan I., 2006, , Universities in NIS of China: evolution, characteristics and challenges. National Research Center for S&T for development, PRC, in
www.fpi.lu.se/_media/en/research/china-power-point-havana-06.pdf

HIKPA (Hong Kong Institute of Certified Public Accountants)), 2006, APlus Intelligence report, March.

Hodson S.., 2008, The Decline & Fall of the West's Internet Age posted on January 18, 2008 in
http://www.winextra.com/2008/01/18/the-decline-fall-of-the-wests-internet-age/

Hong, W., 2006, "Decline of the Center: the Decentralizing Process of Knowledge Transfer of Chinese Universities from 1985-2004" Paper presented at the annual meeting of the American Sociological Association, Montreal Convention Center, Montreal, Quebec, Canada, Aug 10, 2006
Online <APPLICATION/PDF>. 2008-05-07
<http://www.allacademic.com/meta/p103725_index.html>

Hsiung, D. I., 2002, An evaluation of China's S&T System and its impact on the research communisty,, special Report for the environment, S&T Section,US Embassy, Beijing, China

Hu A. G. and . JEFFERSON G.H., Returns to research and development in Chinese industry: Evidence from state-owned enterprises in Beijing, China Economic Review Volume 15, Issue 1, 2004, Pages 86-107

Hung S-W., 2008, Development and innovation in the IT industries of India and China,

Technology in Society, In Press, Corrected Proof, Available online 12 February 2008 http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V80-4RTKMRS-1&_user=1922970&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000055306&_version=1&_urlVersion=0&_userid=1922970&md5=be8724f0db30f123b7bbd870f7f50646#secx1

Jomo K. S. ed. (2007). *Malaysian Industrial Policy*. Singapore University Press, Singapore, and University of Hawaii Press, Honolulu.

Jomo K. S., Chang Y. T., Khoo K. J. with others (2004). *Deforesting Malaysia: The Political Economy and Social Ecology of Agricultural Expansion and Commercial Logging*. Zed Books, London.

Jomo K. S. ed. (1995). *Privatizing Malaysia: Rents, Rhetoric, Realities*. Westview Press, Boulder.

Jomo K. S. with Shyamala Nagaraj eds. (2001). *Globalization Versus Development: Heterodox Perspectives*. Palgrave, Houndmills.

Jomo, K.S. and Wee (2008) "Lessons From Post-Colonial Malaysian Economic Development", paper prepared for WIDER conference on Country Role Models for Development Success, June13-14, Helsinki

Kash, D.E., Augur, R.N., and Li, N. 2004, An Exceptional Development Pattern, Technological Forecasting and Social Change, 71 (8), 777-797

Kenning P. and Plassmann H., 2004, NeuroEconomics,
University of Muenster, in http://129.3.20.41/eps/exp/papers/0412/0412005.pdf

Knell M., Fagerberg J., Srholec M., (2007): The competitiveness of nations Why some countries prosper while others fall behind In World Development, Vol 3 issue 10

Kuijs L., , Mako W., , and Zhang C., 2005, SOE Dividends: How Much and to Whom? World Bank's Beijing Office, in http://siteresources.worldbank.org/INTCHINA/Resources/318862-1121421293578/SOE_En_bill.pdf

Keynes, J. M.(1971-79), *The Collected Writings of John Maynard Keynes,* 29 vols., ed., D. E. Moggridge for the Royal Economic Society, London: Macmillan.

Khan, H. A.(2013)Development Strategies: Lessons from the Experiences of South Korea, Malaysia, Thailand and Vietnam, in Augustin K. Fosu ed. *Achieving Development Success*, Oxford University Press:119-132.

Khan HA (2008a). "Building an Innovative Economy through Managed Creative Destruction: A Theory with Applications to South Korea". Accessed April 2008 at: http://econpapers.repec.org/paper/pramprapa/7713.htm

Khan ,H.A.(2008b)"Making Globalization Work: Towards Global Economic Justice", Cosmopolis, May 2008 http://ideas.repec.org/p/pra/mprapa/7864.html

Khan,H. A.(2008c) "China's Development Strategy and Energy Security", WIDER research Paper
http://www.wider.unu.edu/publications/working-papers/research-papers/2008/en_GB/research_papers_2008/

Khan, H. A. 2005," Case Studies in Globalization, Convergence, and Superconvergence of Emerging Technologies presentation at the International Workshop on Emerging Technologies: The Global Challenges of Convergence, Bangkok,14-15 Dec.2005.
http://www.apecforesight.org/emerging_tech/docs/HaiderPresentation_Dec05.ppt

Khan, H. A (2002) "Innovation and Growth in a Schumpeterian Model", Oxford Development Studies, Vol. 30, no. 3, 2002: 289-306.

Khan HA (2004a). *Innovation and Growth in East Asia: The Future of Miracles.* Houndsmills and New York: Macmillan/Palgrave.

Khan HA (2004b). *Global Markets and Financial Crisis in Asia: Towards a Theory for the Twenty First Century*. Houndsmills and New York:Macmillan/Palgrave.

Khan HA (2003a). Technology and Modernity: Creating Social Capabilities in a POLIS. In Misa T ed. *Technology and Modernity*, Cambridge: The MIT Press, Chapter12.

-------(2003b) "What can the African countries learn from the macroeconomics of foreign aid in Southeast Asia?", Aryeetey, E., Court, J., Nissanke, M. and Weder, B., *Asia and Africa in the Global Economy*, Tokyo, UNU Press.

Khan HA (2002). "Innovation and Growth in a Schumpeterian Model". *Oxford Development Studies* 30(3): 289-306.

Khan HA (1998). *Technology, Development and Democracy: Limits to National Innovation Systems in the Age of Postmodernism*. Cheltenham, United Kingdom: Edward Elgar.

Khan HA (1997). *Technology, Energy and Development: The South Korean Transition*. Cheltenham, United Kingdom: Edward Elgar.

Khan HA(1983)"Technology, Energy, Distribution and Balance of Payments:A Macroeconomic Framework", Unpublished dissertation, Cornell University, Ithaca, New York.

Lee, Keun(2008) "Can Korea be a Role Model for Development?A "Capability-based View" on Korea", paper prepared for WIDER conference on Country Role Models for Development Success, June13-14, Helsinki

Lee, Keun, 2006, “The Washington Consensus and East Asian Sequencing: Understanding Reform in East and South Asia,” J. Fanelli and G. McMahon, eds. *Understanding Market Reforms* Vol. 2: Palgrave, 2006 .

Lee, Keun A., 2006, “Understanding Reform in 6 Asian Countries: Washington Consensus vs. East Asian Sequencing,” J. Fanelli and G. McMahon, eds. Understanding Market Reforms Vol. 2: Palgrave..

Lee, K., Hanh D., and Yifu Lin J., 2002, : "Is China following the East Asian Model? A Comparative Institutional Analysis Perspective" China Review 2: no.1.

Lee K., 2006 b , China's Economic Catch-up: Washington Consensus or the Bejing Consensus, Selected Papers from the 2nd World Forum on China Studies (Abstracts), Panel 2, Exploration into the Theory and Practice of the Mode of China’s Development, in http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN024930.pdf

Li-Hua R., 2008,, China's science and technology capacity building: global perspective and challenging issues (book review), **Journal:** Journal of Technology Management in China
Vol : 3 **Issue:** 1

Li-Hua R. and Simon D., 2007, Benchmarking China firm competitiveness: a strategic framework, Journal of Technology Management in China. Bradford: 2007. Vol. 2, Iss. 2.

Li K., Hu L., Chi J., 2007, Major sources of production improvement and innovation growth in Chinese enterprises, Pacific Economic Review, Vol. 12, Iss. 5.

Li Y., Liu Y., and Ren F., Product innovation and process innovation in SOEs: evidence from the Chinese transition, The Journal of Technology Transfer, Vol.32, Issue 1.

Liu X. and White S., 2001, Comparing innovation systems: a framework and application to China’s transitional context, Research Policy Vol.30, Issue 7, No.30, pp. 1091–1114.

Lundin N. and and Sylvia Schwaag Serger S., 2007, Globalization of R&D and China – Empirical Observations and Policy Implications
IFN Working Paper No. 710, 2007

Mayer, Jörg(2002). "The Fallacy of Composition:A Review of the Literature", *The World Economy*, Vol.25,pp.875-94.

Ma W., 2004, From Berkeley to Beida and Tsinghua: The development and governance of public research universities in the US and C, Beijing, Educational science Press.

Marx K., 1975, Critique of the Gotha Program, in
http://www.marxists.org/archive/marx/works/1875/gotha/index.htm

Mayberry T., Wang S., and Suh B., 2006, Special Report: China III: Getting IT Right the First Time - A Bold New Agenda for China's CIOs Outlook Journal, May 2006

Ministry of Science and Technology of China (MOST), 2005, Documents of state policies on science and technology.

Motohashi K., 2005, R&D of Multinationals in China: Structure, Motivations and Regional Difference, RIETI Discussion Paper Series 06-E-005, in http://www.rieti.go.jp/jp/publications/dp/06e005.pdf

Motohashi K. and Kazuyuki X., 2007, China's innovation system reform and growing industry and science linkages, Research Policy, Volume 36, Issue 8, October 2007, Pages 1251-1260.

Nelson, R. (1964), "Aggregate Production Functions and Medium-range Growth Projections," American Economic Review, September, 54, 575-606.

Nelson, R. (1968), "A Diffusion Model of International Productivity Differences in Manufacturing Industry," American Economic Review, 58:1219-48.

Nelson, R. (1980), 'Production Sets, Technological Knowledge, and R and D: Fragile and Overworked Constructions for Analysis of Productivity Growth?', American Economic Review, 70: 62-7.

Nelson, R. (1981), 'Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures', Journal of Economic Literature, 19/3: 1029 64.

Nelson, R. (1989), "What is Private and What is Public about Technology?" Science, Technology and Human Values, 14(3): 229-41.

Nelson, R. (1992), "U.S. Technological Leadership: Where Did It Come from and Where Did It Go?" Scherer, Frederick M. and Mark Perlman (1992), Entrepreneurship Technological Innovation. and Economic Growth: Studies in the Schumpeterian Tradition Ann Arbor: The University of Michigan Press: 25-50.

Nelson, R. (1993), "Technical Change as Cultural Evolution," Ross Thomson, ed., Learning and Technological Change. New York: St. Martin's Press.

Nelson, R. ed. (1993), National Innovation Systems: A Comparative Analysis. Oxford: Oxford University Press.

Nelson, R. (1994), "What has been the Matter with Neoclassical Growth Theory," in G. Silverberg and Luc Soete, eds. (1994), The Economics of Growth and Technical Change: Technologies, Nations, Agents, Aldershot, U.K.: Edward Elgar: 290-324.

Nelson, R. (1995), “Recent Evolutionary Theories About Economic Change” Journal of Economic Literature, pp. 48-90.

Nelson, Richard R and S. Winter (1973), “Recent Exercises in Growth Accounting: New Understanding or Dead End?”, American Economic Review, 73:462-468.

Nelson, R. ----- (1974), 'Neoclassical vs. Evolutionary Theories of Economic Growth: Critique and Prospectus', Economic Journal, 84: 886-905.

Nelson, R. ----- (1977), "In Search of a Useful Theory of Innovation." Research Policy 6: 36-76.

Nelson, R. ----- (1982), An Evolutionary Theory of Economic Change, Cambridge: MA, Harvard University Press.

OECD 2006, Science, Technology and Industry Outlook 2006

Pasinetti L., 1962, Rate of Profit and Income Distribution in Relation to the Rate of Economic Growth ,The Review of Economic Studies, Vol. 29, No. 4 (Oct., 1962).

Razmi, Arslan and Robert Blecker (2006)."Developing Country Exports of Manufactures:moving up the export ladder to escape the fallacy of composition?", *Journal of Development Studies*, Vol.44, No.1, January:21-48.

Research Technology Management (RTM) 2007, China's 15 Year Science and Technology Plan, Arlington:Nov/Dec 2007. Vol. 50, Iss. 6, p. 70 (1 pp.)

Ren L., , L., Koos Krabbendam K., de Weerd-Nederhof P., 2006, Innovation practices success in China: the use of innovation mechanisms in Chinese SOEs, Journal of Technology Management in China, Volume: 1 Issue: 1 Page: 76-91

Sen A., (1999),. Development As Freedom. New York: Knopf.

Steward, Julian H., *Theory of Culture Change: The Methodology of Multilinear Evolution*. University of Illinois Press, 1990.

Shanghai Daily 2007, September 14, SOE Dividends to Bolster Social Security Funds).

Shaomin Li S.and Judy Jun Wu J., Why China Thrives Despite Corruption, Far Eastern Economic Review. Hong Kong: Apr 2007. Vol. 170, Iss. 3;

Suh B. (ed.), 2008, American companies are falling behind in technology,. Financial Times. London (UK): Feb 13, 2008. pg. 9

Thoburn, J.T.(2008), "Viet Nam", paper prepared for WIDER conference on Country Role Models for Development Success, June13-14, Helsinki
Thoburn, J.T., K. Sutherland and Nguyen Thi Hoa (2007), 'Globalisation and restructuring in the textiles sector on households in Vietnam: impacts on households', *Journal of the Asia Pacific Economy*, vol.12, no.3, August,: 345-366

Trigram.wordpress.com 2007, Phone design: innovation on fast-forward? http://trigram.wordpress.com/2007/11/03/phone-design-innovation-on-fast-forward/

Tsai K. 2008, China's Complicit Capitalists, Far Eastern Economic Review, (Vol. 171, Iss. 1, 2008).
Wang, J-H., 2006, China's dualist model on technological catching up: a comparative perspective: The Pacific Review, Volume 19, Number 3, September

Warr, Peter(2008) "Thailand's Development Strategy and Growth Performance", paper prepared for WIDER conference on Country Role Models for Development Success, June13-14, Helsinki
Warr, Peter (1993) 'The Thai Economy' in Peter Warr (ed.) *The Thai Economy in Transition,* Cambridge University Press, Cambridge, 1-80.
Warr, Peter (1999). 'What Happened to Thailand?', *The World Economy*, 22 (July), 631-650.
Warr, Peter (2005) 'Boom, Bust and Beyond' in Peter Warr (ed.) *Thailand Beyond the Crisis*,
Routledge, London, 3-65.

Weiss, John and H. A. Khan eds.(2006) *Poverty Strategies in Asia: A Growth Plus Approach,* Cheltenham: Edward Elgar and ADBI.

Wu W., 2007, Building Research Universities for Knowledge Transfer - The case of China, in Shahid Y. and Nabeshima K., (eds), 2007, How Universities Promote Economic Growth, The World Bank, Washington DC

Xia L. and Li S., 2008, The Roles and Performance of State Firms and Non-State Firms in China's Economic Transition**,** World Development., Vol. 36, Iss. 1.

Zeng D.Z., and Wang S., 2007, China and the Knowledge Economy: Challenges and Opportunities, World Bank Policy Research Working Paper 4223, May 2007.

Zhang J., 2003, The development of high-tech enterprises in China's universities, Wuhan, China, Huazong Science and Technology University Press.

Zhang W., 1998, China's SOE Reform: A Corporate Governance Prespective, 6. Technical Report Series 1998-5, The Asia-Pacific financial markets research centre, available in http://www.gsm.pku.edu.cn/wuan1/EnglishPapers/SOEREF.rtf